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THE EAST MIDLAND GEOGRAPHER

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INDUSTRY AND TRANSPORT IN DERBY

B. J. TURTON

An analysis of the significance of transport is essential in any reasoned account of the location factors associated with an industrial plant. The economic geographer should thus be acquainted with the types of transport employed by the industrialist and with the relationships between transport, sources of materials and location of markets. The general significance of transport as a location factor can probably best be assessed by considering transport costs as a proportion of the total cost structure of the plant, but information on costs is seldom accessible to the geographer in the form of published data. It is, therefore, usually necessary to look to the individual firm for information, although detailed cost structures as such are very rarely revealed. This article is based upon limited statistical material obtained in this manner and consists of an analysis of the relative importance of road and rail transport to industrialists in Derby, one of the three principal industrial centres in the middle Trent basin(1). The investigation is confined to the Derby textile and metal industries(2), which in 1958 together accounted for 82 per cent. of employment in manufacturing industry and 46 per cent. of total employment within the Derby Labour Exchange Area(3).

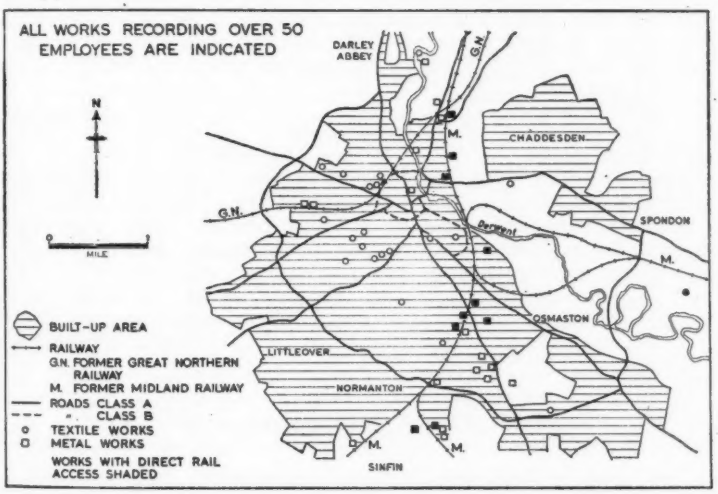

Figure 1

Data relating to the use made of road and rail facilities were obtained from firms employing over 100 persons in the textile and metal industries, these establishments representing 37 per cent. of all textile works and 33 per cent. of all metal works(4). In view of the reluctance of managements to disclose details of actual freight tonnages conveyed the number of persons employed by each establishment has been used in Figure 1 to provide some broad indication of the scale of operation. It must not be assumed, however, that there is any fixed relationship between numbers of workers and the quantities of freight.

Location of the Textile and Metal Industries

The location of all establishments with over 50 employees is shown in Figure 1. The groupings of engineering works alongside the railway to the north-east and south-east of the town centre contrast with the dispersed pattern of textile factories located in the central and western districts of the built-up area. A second contrast between the two industries lies in the general absence of rail-connected textile factories and the numerous engineering works which are equipped with private rail sidings.

Firm's reference number (Fig. 2.)	*Industry*	*Date of establishment in Derby*
1	Iron founding	1873
2	Iron founding	1849
3	Iron founding	1908
4	Iron founding	1868
5	Alloy casting	1949
6	Brass founding	1844
7	Aircraft engines	1908
8	Railway carriages	1876
9	Railway locomotives	1839
10	Heating and ventilating equipment	1924
11	Piping equipment	1907
12	Electrical cables	1929
13	Power press equipment	1939
14	Sugar milling machines	1860
15	Chains, conveyors	1880
16	Heating equipment	1914
17	Diesel engines	1948
18	Mining equipment	1820
19	Rayon, chemicals and plastics	1917
20	Cotton	c.1783
21	Hosiery	1931
22	Hosiery	1898
23	Hosiery	1912
24	Hosiery	1936
25	Hosiery	1912
26	Lace	1825
27	Lace	1912
28	Narrow fabrics (tapes, etc.)	1798
29	Narrow fabrics (tapes, etc.)	1860
30	Narrow fabrics (tapes, etc.)	1926
31	Narrow fabrics (tapes, etc.)	1883
32	Narrow fabrics (tapes, etc.)	1914
33	Narrow fabrics (tapes, etc.)	1926
34	Narrow fabrics (tapes, etc.)	1925

The large artificial fibre plant at Spondon accounts for approximately 65 per cent. of total employment in the Derby textile industry and is the only textile works in the town to have direct rail access. A wide range of chemicals and plastics is also produced at this plant, whereas the much smaller textile factories within the town are concerned mainly with the manufacture of hosiery, lace and narrow fabrics (see Table). The lace and narrow fabrics industries were first introduced to Derby on a factory scale in the late eighteenth and early nineteenth centuries, but were preceded by the now defunct silk industry. In view of its dependence upon water power the latter industry had been established alongside the Derwent and its tributary, the Markeaton Brook, and many of the early lace and hosiery mills adopted sites in the same

areas, although by 1840 most of these mills were steam powered(5). A 'textile quarter' to the west of the town centre had thus emerged by 1840 and continued to attract other mills, although the need for water power had passed. The development of hosiery factories in Derby dates from the second half of the nineteenth century, but these later mills were also built in this textile quarter and rarely occupied rail-side sites.

The sites of metal manufacturing and engineering works established between 1840 and the First World War are, with few exceptions, alongside the railway. Derby was first provided with railway facilities in 1839 and the locomotive works founded in the following year appropriately represents the first significant orientation towards this new means of transport. Most of the engineering works introduced to the town in the later nineteenth century also occupied sites adjacent to, and linked with, the lines of the former Midland Railway system, and the Litchurch district to the south-east of the town centre grew as the principal industrial area of Derby during this period. On the other hand no works of importance were established alongside the Derby branch of the former Great Northern Railway, which was opened in 1875. This was due to the comparative lateness of its construction and to the course of this railway through an already built-up area; the Midland lines on the south-eastern outskirts of the town were, on the other hand, bordered by undeveloped land. Another factor discouraging works from establishing themselves alongside the Great Northern line was that, whereas the latter was a penetrating line isolated from the main trunk route of the G.N. system, the Midland lines in Derby were at the focus of a system providing direct routes to London, the Midlands and northern England.

Even with the declining significance of the railway as a factor influencing industrial location in the twentieth century the area adjacent to the Midland line in the south-east of Derby continued to attract engineering works, although many of the works built in this area since 1920 have not been equipped with sidings despite their proximity to the railway. The reasons for the continued growth of industry in this south-east area can be seen in its working-class character and established engineering traditions, coupled with the availability of land for industrial sites(6).

The Assembly of Raw Materials.

Figure 2 (A) shows the proportional use made of road and rail facilities in the assembly of materials by establishments with over 100 employees. Road haulage is clearly the dominant means of transport and there are few instances where the greater proportion of materials is delivered by rail.

Thirteen of the fourteen textile concerns returning information receive over 75 per cent. of their incoming supplies by road. The only firm receiving the larger part of its supplies by rail (No. 25) is a small branch of a Leicester hosiery company with similar branches in Kegworth, Mansfield and Middlesbrough. With the exception of certain heavy chemicals all raw materials are conveyed to the Spondon plant by road.

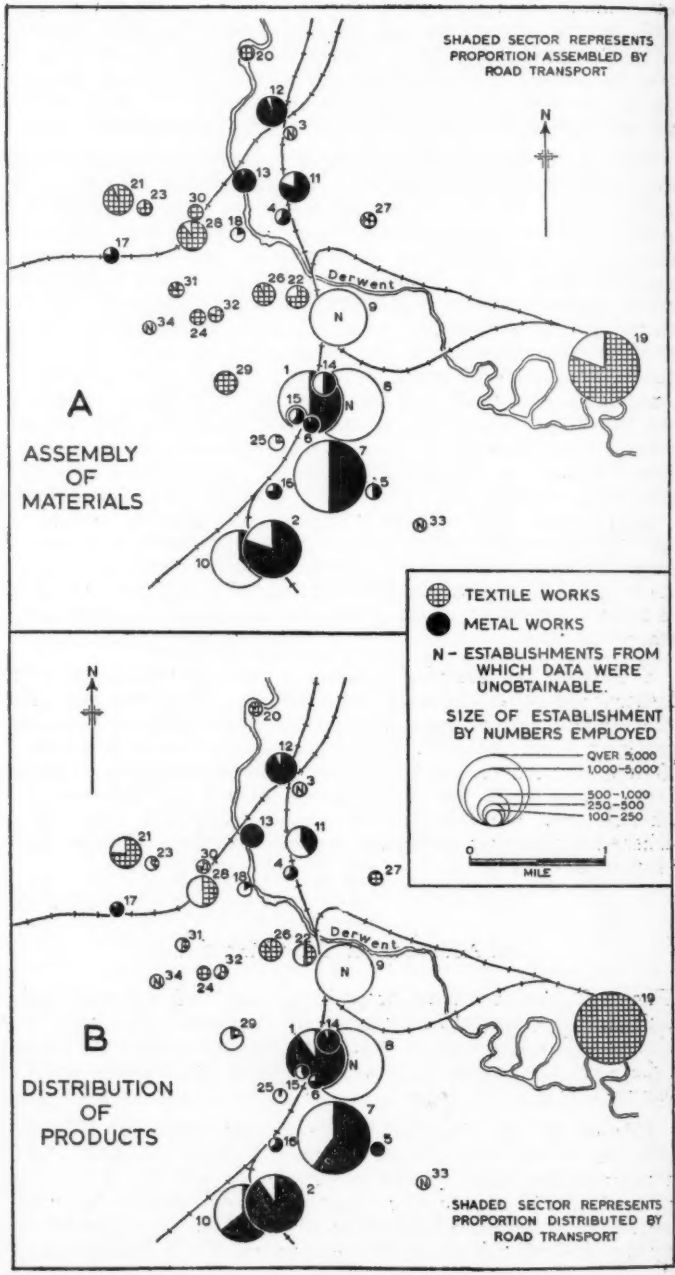
SHADED SECTOR REPRESENTS PROPORTION ASSEMBLED BY ROAD TRANSPORT
N
Derwent
A
ASSEMBLY OF MATERIALS
TEXTILE WORKS
METAL WORKS
N – ESTABLISHMENTS FROM WHICH DATA WERE UNOBTAINABLE.
SIZE OF ESTABLISHMENT BY NUMBERS EMPLOYED
OVER 5,000
1,000–5,000
500–1,000
250–500
100–250
0
1
MILE
B
DISTRIBUTION OF PRODUCTS
SHADED SECTOR REPRESENTS PROPORTION DISTRIBUTED BY ROAD TRANSPORT

Figure 2

Although road transport is also used to assemble most of the raw materials required by the metal industries, the railway is employed to a greater extent than in the textile industry. Nevertheless, of the fifteen firms returning information, only two (Nos. 10 and 18) receive over 50 per cent. of their supplies by rail and four are served by road and rail transport in equal proportions. Iron foundries, despite the heavy nature of their raw materials, appear to rely upon road transport for deliveries to the same extent as many of the specialised engineering concerns where incoming materials are less bulky. Rail haulage is most extensively used in the deliveries to a small mining equipment firm (No. 18), whose works have occupied the same site in the central part of the town since 1820, *i.e.*, since the pre-railway era. In contrast, the other concern receiving most of its incoming freight by rail is an engineering plant (No. 10) established in 1924 on the southern outskirts of the town.

The Distribution of Products

Road haulage is used to distribute the greater proportion of the products of both textile and metal industries, but at the same time the railway generally plays a more important part in distribution than it does in the assembly of materials (Fig. 2(B)).

Within the textile industry five concerns (Nos. 19, 20, 24, 26 and 27) distribute over 80 per cent. of their goods by road, compared with nine receiving a similar proportion of their materials by road. Three firms (Nos. 22, 28 and 31) make equal use of road and rail services for distribution, and three concerns (Nos. 23, 25 and 29) despatch most of their goods by rail. Rail facilities are used to the greatest extent by the hosiery factory (No. 25) already noted as receiving most of its materials by rail.

Five metal works (Nos. 2, 4, 12, 16 and 17) appear to employ road and rail services for distribution in approximately the same proportions as they receive incoming materials, with road transport dominating. In three cases (Nos. 11, 15 and 18) most goods are distributed by rail; the small engineering works (No. 18) which also receives most of its incoming freight by rail falls within this category but the other two instances obtain most of their supplies by road.

Discussion

It is clear, therefore, that the greater proportion of the freight delivered to and despatched from the Derby textile and metal industries is conveyed by road. In the absence of any detailed information on the transport costs of individual firms the more general factors affecting choice of method of transport must be considered. Usually the primary consideration of the manufacturer will be the cost of his transport, followed by the question of the relative convenience of road and rail facilities. These two factors will be considered in relation to the type of freight conveyed, to the frequency of delivery and despatch which is required, and to the distance of the plant from the principal sources of supply and from markets. The type of transport employed in assembly of materials will usually depend upon the preference of the supplier, whereas the method of despatch will be determined by the manufacturer.

Since the freight rates of road hauliers are in general lower than those quoted by the railways most manufacturers will prefer to employ road transport, a fact which explains the extensive use of this means of carriage which has been seen in this article. When the cost of transport is related to the type of freight carried a distinction can be drawn between the "light" character of the goods involved in the textile industry and the more bulky freight associated with the metal working industry. Some indication of this distinction is provided by Sargent Florence's grading of industries according to the weight of material used per year per operative(7). Within a table of 81 industries graded on this basis the hosiery and lace industries rank fifth and sixteenth respectively, with both activities using less than five tons of material per year per operative. The iron founding and engineering industries appear much lower in the table and use between 18 and 55 tons per operative.

It is understandable, therefore, that the wool, cotton and synthetic fibres forming the raw materials of the hosiery, lace and narrow fabrics industries are generally delivered by road transport, where charging is broadly based upon weight in relation to space occupied. Rail charges are very complicated in their application, but the traditional basis of the rate system is to charge according to the value and not to the bulk of freight carried. It might be reasoned, therefore, that the railway would be preferred for the carriage of many of the relatively low value raw materials required by the Derby metal industries, but in fact there is no detectable or consistent relationship between the type of materials involved and the mode of transport used to convey them. For example, of the four iron foundries returning information only one receives most of its incoming materials by rail.

When the convenience of facilities offered by road and rail services are examined several broad contrasts emerge. Railway haulage in Britain is a monopoly undertaking whereas several methods of road haulage are available to the manufacturer. Unless a private siding has been installed goods consigned by rail must be trans-shipped at the rail depots, and collection and delivery dates are determined by the railway authorities. Of the seven metal working plants equipped with sidings in Derby, for which information was available, only four distribute over one third of their goods by rail to-day, while three plants with sidings now dispatch over 80 per cent. by road.

The manufacturer consigning his goods by road may make use of one or more of a number of services. Possession of a "C" licence enables a manufacturer to operate his own vehicles (but solely for the carriage of his own goods) and this system has the obvious advantages of immediate availability of transport at all times, the maintenance of a "personal contact" between producer and consumer and value as an advertising medium for the firm. A modification of this system is the contract hire arrangement whereby a manufacturer hires vehicles from a haulage contractor for his exclusive use. Many of the larger iron and steel and textile companies in Britain operate their own road transport services in this way, a fact which helps to explain the dominance of road services in delivery of materials to Derby firms. The instance of the Spondon rayon firm supplying consumers, in the form of hosiery firms, by company-owned road services is logical in view of the proximity of these firms, and is a straightforward example of juxtaposition of supplier and consumer leading to lower transport costs(8).

Alternatively, a manufacturer can employ a "public carrier" to transport his goods; this section of the road transport industry comprises a large number of private hauliers and the state-owned British Road Services undertaking. Although the manufacturer does not control the transport service in this case the services available are sufficiently flexible to provide for the requirements of most industrialists.

The dominance of road transport in deliveries to the Derby textile and metal industries results largely from the extensive use of "C" licence facilities by suppliers. When distribution is considered the same use of company-owned transport explains many cases where road services are mainly used to despatch goods. A number of the iron foundries and certain hosiery and narrow fabrics factories which are branches of larger textile concerns are served by company-owned transport in this way. Eight of the Derby lace, hosiery and narrow fabrics concerns returning information are, in fact, owned by companies with headquarters outside the town, and certain of these companies bring consignments of goods by road from all branches to a central warehouse from which final distribution is made. The domestic consumer market, for which many of these textile factories cater, is widely dispersed and involves the despatch of a large number of small consignments to many centres throughout the country. Where company-owned transport is not available, as in the case of many of the small independent Derby firms, rail services are often used to despatch at least 50 per cent. of production (*e.g.*, Nos. 22, 23, 28, 29).

Information on the role of transport in the movement of freight to and from the two British Railways workshops in Derby was unobtainable, but since both plants are concerned with the manufacture and repair of railway vehicles the exclusive use of rail facilities for distribution is obvious. In any case these two plants are not readily comparable with other engineering works in Derby since the greater proportion of their capacity is normally devoted to repairing and not to vehicle building.

Conclusions

As this article has been based only upon data supplied by establishments employing over 100 persons it is recognised that many works of smaller size may make a proportional use of transport facilities which differs markedly from that recorded by the concerns shown in Figure 2. However, the evidence obtained from these larger units does probably provide a useful indication of the relative importance of road and rail services to industrial plants in Derby generally.

The overall dominance of road transport in freight movements to and from the town is of especial interest when considered in relation to the status of Derby as a railway focus. Although industry on a factory scale existed in the town before the railway network was established the growth of Derby as an industrial centre was very strongly assisted by its focal railway position during the nineteenth century. To-day, however, any special attraction which this attribute might be considered to offer to the industrialist would appear in fact to be of much less importance than

hitherto. In the opinion of the British Transport Commission the main competition to rail haulage to-day is not so much from the road haulage contractor as from the increasing numbers of traders carrying their own goods under a "C" licence(9). Whether the railways, through a combination of prompter services and more attractive freight rates, can counter this competition is a question dependent upon the success of the current modernisation plan and upon the preferences of the individual manufacturer and supplier.

NOTES

(1) For an analysis of employment structures see E. M. RAWSTRON, The employment structure of Nottingham, Derby and Leicester, *East Midland Geographer*, 8 (Dec. 1957) 45-48.

(2) "Metal industries" in the context of this article are defined as metal manufacturing and all engineering (including vehicle-building) industries.

(3) The Derby Exchange Area covers Derby County Borough, adjoining suburbs and neighbouring rural areas.

(4) Numbers of firms were obtained from H.M. Factory Inspectorate, Derby District.

(5) F. WARNER, *The silk industry of the United Kingdom* (1921) pp.198-200. Also, *Return of mills and factories*, British Parliamentary Papers, 1839, XLII.

(6) E. C. VOLLANS, Derby—a railway town and regional centre, *Transactions and Papers*, 1949, Institute of British Geographers, 15 (1951), p.107.

(7) P. SARGENT FLORENCE, *Investment, location and size of plant* (1949) pp.9-10.

(8) An account of the Spondon plant is given in H. A. MOISLEY, The rayon industry in Great Britain, *Geography* 34 (1949), 80-88.

(9) BRITISH TRANSPORT COMMISSION, *Re-appraisal of the plan for the modernisation and re-equipment of British Railways* (Cmd. 813, H.M.S.O., 1959), p.22.

THE INTENSE THUNDER RAINS OF 1st JULY, 1952, IN THE NORTHERN MIDLANDS

F. A. Barnes

An earlier article in the East Midland Geographer(1) examined the effect of heavy thunder rains in western Derbyshire in August, 1957, mainly from a physiographic standpoint. This paper presents an analysis of the violent thunderstorms of 1 July, 1952, with special attention to the factors that were responsible for the exceptional intensity of the rain and for its pattern of distribution. The exercise is worthwhile because such unusual storms may exemplify in an exaggerated form the meteorological controls of commoner weather conditions.

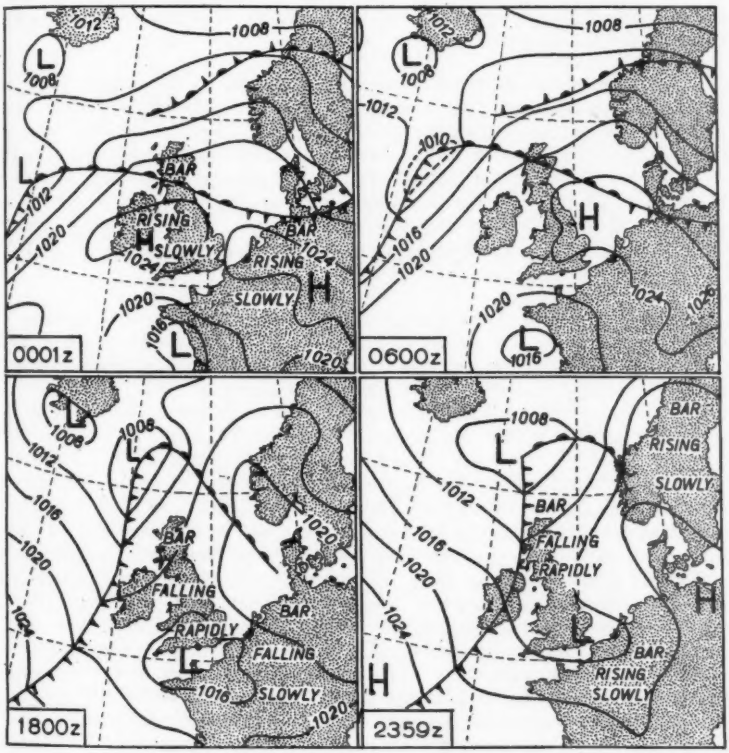

Figure 1—Surface isobaric charts for 1 July, 1952.

The mainly convectional rainfall of the English summer of 1952 culminated in the disastrous Lynmouth downpour of 15-16 August, but the most notable storm in Derbyshire and Nottinghamshire was on 1 July. The falls of rain nowhere approached those of the Lynmouth storm in amount, but their intensity was "very rare" at some stations in south Derbyshire and Nottinghamshire, "remarkable" in many places,

and "noteworthy" over a wide area(2). They were accompanied by spectacular lightning, and locally by very large hail and destructive winds associated with a well-developed squall front.

Development of the General Weather Situation

In the early morning of 1 July a wave depression west of the British Isles was moving north-eastwards, its warm front travelling north over Scotland and its cold front still well west of Ireland (Fig. 1)(3). A ridge from central Europe was tending to withdraw, while a shallow depression which had moved from Spain to western France and Biscay was turning northwards. The pressure gradient over England was very slack. By evening (Fig. 1) the cold front was nearing western Ireland, and the Biscay Low, centred over the Channel, was moving north-east towards the North Sea.

Thunderstorms affected south-west England in the morning of 1 July, and spread north-north-east into the west Midlands during the afternoon, and into Yorkshire and north-east England in the evening (Fig. 2A)(4). Thundery activity also occurred in Wales and Ireland, and later in Scotland, but it lacked the violent character of that in the Midlands. Thunderstorms developed only on the west and north-west sides of the Biscay Low, and moved in almost the opposite direction from the surface airflow in that sector of the Low, a feature explained by reference to upper air conditions.

Early on 1 July there was a strong south-west thermal gradient aloft north-west of the British Isles (Fig. 3). West and south-west of the Biscay Low there was a low tropopause, and an upper pool of cold air which moved north or north-north-east, causing scattered thunderstorms to break out as it passed over much warmer air. The upper cold pool later turned north-east across northern England, and by 1500 G.M.T. 2 July it was over the central North Sea. The associated changes in stratification of temperature and humidity at various stations are shown in the lower part of Figure 3. At 0300 G.M.T. 1 July dry subsident air in the middle levels over Scotland and Northern Ireland contrasted with much moister and cooler air at Camborne, where the upper cold pool was encroaching. Thunderstorms were already occurring in the South-west Approaches, where the upper cold pool was above very warm lower air moving off the continent round the Biscay Low. By mid-afternoon the middle levels at Liverpool had become colder, but the resulting thunderstorms there were not severe. A moist layer between 650 and 500 mb (about 10,000 and 24,000 feet) had spread over central and eastern England, causing a very widespread outbreak of altocumulus castellatus cloud; but despite afternoon surface temperatures which locally exceeded 90 degrees F. thunderstorms did not form in southern England (Fig. 2 F and B). They were apparently prevented by the very dry layer, probably of subsided anticyclonic air, which had come in from the south-east at about 750 mb. (6,000 feet) below a wind shear, as the circulation of the Biscay Low extended to the area. Early on 2 July the moist cold pool had moved away from southern England, but at Liverpool and in Northern Ireland even colder moist air had arrived from the west, while deep moist cold air covered Leuchars.

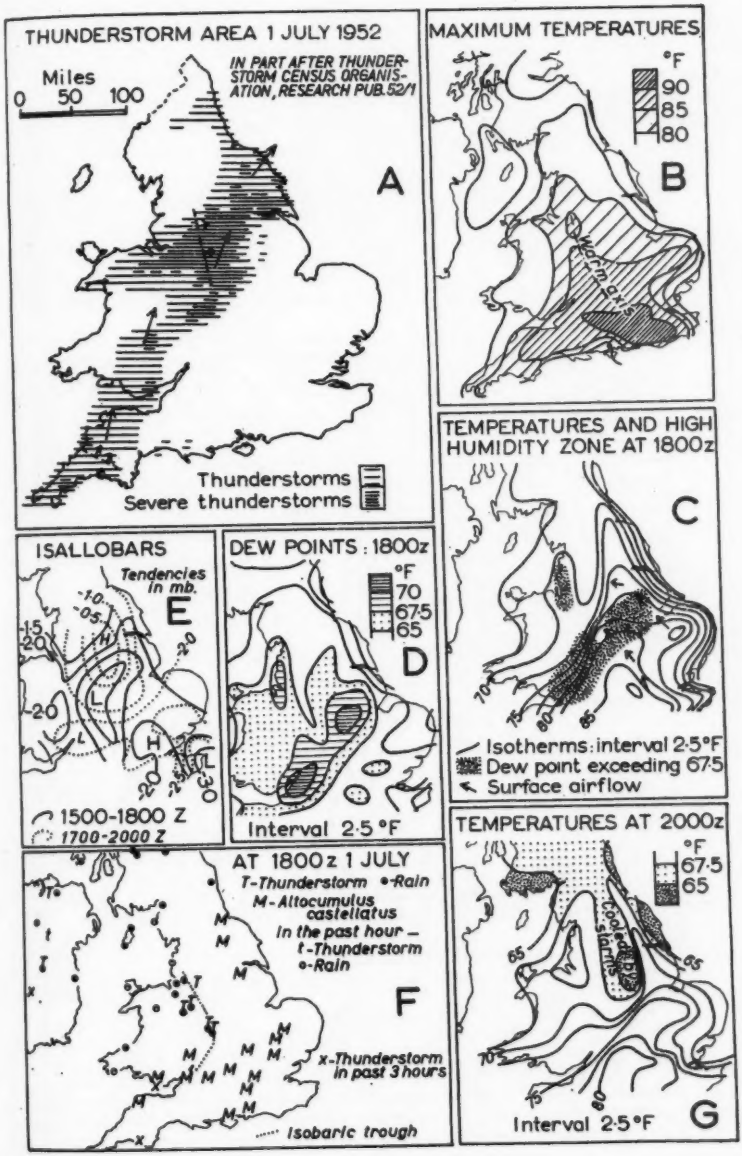

Figure 2—The thunderstorm area, and patterns of temperature, humidity, pressure change and weather at various times on 1 July, 1952.

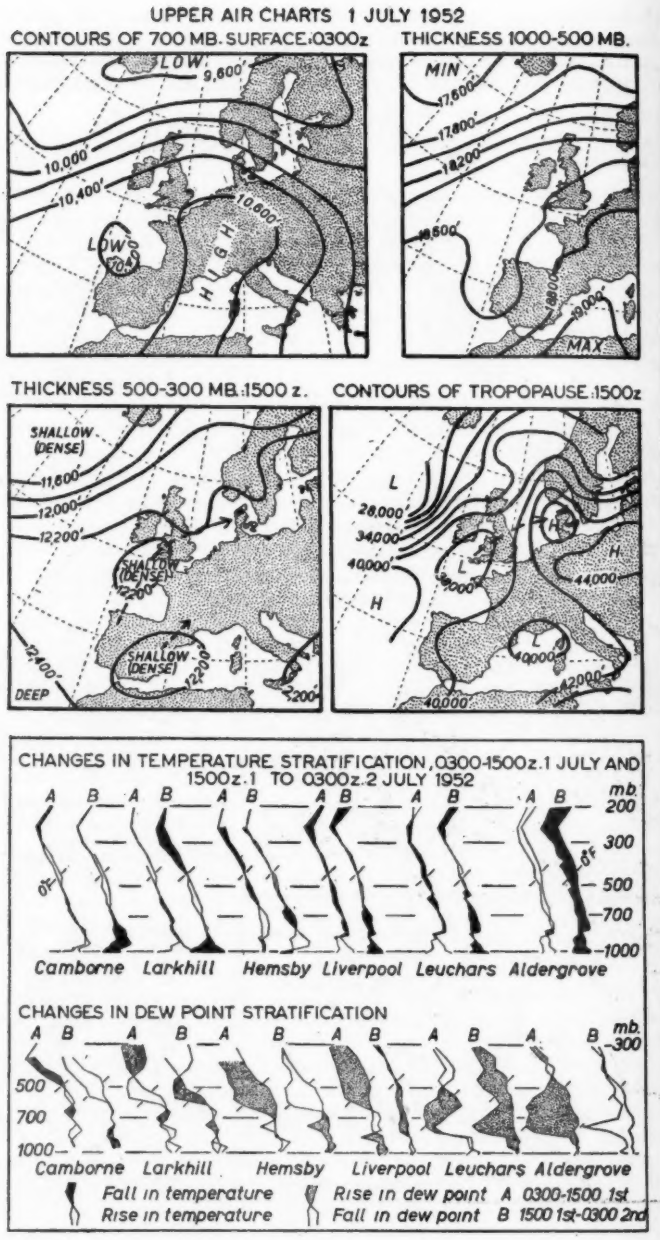

Figure 3— Upper charts, 1 July and changes in temperature and humidity stratification, 1 to 2 July, 1952.

The Local Synoptic Situation in the Midlands

The general thundery activity resulted from advection of moist upper air across warmer, humid surface air flowing along a different track, but this does not explain the varying intensity of the storms, or their arrangement along lines in the Midlands. The belt of maximum activity from Cornwall to Yorkshire (Fig. 2A) was a zone of maximum convergence between warm, very moist surface air from the south-east, and the upper flow from south-south-west. This zone of maximum action extended north-east with the upper cold pool. Its synoptic character is revealed by more detailed charts shown in Figure 4(5).

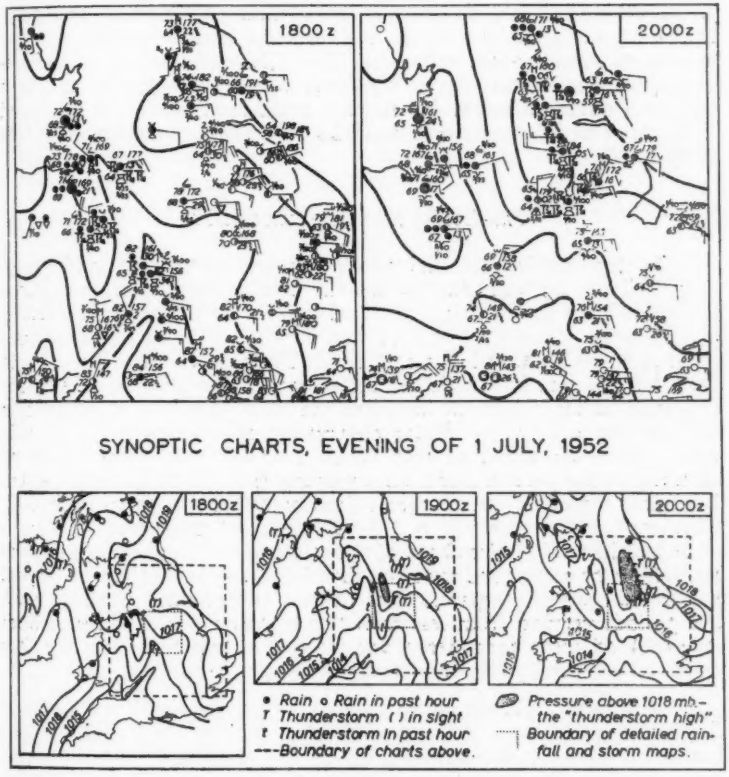

Figure 4

At 1800 G.M.T. 1 July, when a linear distribution of thunderstorms first became apparent in western England, a sharp trough extended north from the Low to the Birmingham area, and then north-north-west into Lancashire. As a whole the trough probably marked the boundary of some critical depth of the upper cold pool, which was moving north-north-east, turning a little to the right. Succeeding charts (Fig. 4) show that while the section of the trough south of Birmingham became indistinct, that from Birmingham to Lancashire moved eastwards at

increasing speed, associated with a line of violent storms which crossed the north Midlands. In northern England and southern Scotland the rain was more prolonged and less intense, and was of that instability type which breaks out over wide areas.

The cold, moist upper mass, shallow and layered at its periphery, was advected north-east across heated England above a very well marked wind shear. Its tendency to turn eastwards was caused by an increasing eastward component in the thermal wind aloft, introduced by the simultaneous northward flow of very warm surface air, and eastward advance of cool upper air well to the north. The lower air entering England from south-east or south-south-east was subjected to its most prolonged surface heating in a tongue extending to the west and north Midlands, the area of maximum heating being elongated along a north-by-west to south-by-east axis (Fig. 2B). Upward motion, and consequently convective activity, is especially favoured near the axis of a tongue of warm surface air(6), and the thunderstorm line first developed along this axis in western England. Its subsequent movement is shown in Figure 4.

Pre-Cold Frontal Squall Lines

On this occasion the surface air was unusually warm and humid (Fig. 2 C and D), and consequently the thunderstorms were exceptionally intense, but the situation described above is not uncommon in Britain in some form. It is a sub-type of that in which lines of thunderstorms occur in warm air ahead of a cold front. The type area for the pre-cold frontal squall line is the United States east of the Rockies where, for geographical reasons, such lines are the chief scene of thunderstorm and tornado activity(7). Radar observation shows that in the Middle West convection ahead of cold fronts normally takes the form of several roughly parallel storm lines varying from 10 to 200 miles apart. The most vigorous line is conventionally called the instability line. Characteristically it is 300 to 350 miles long, of the order of 10 miles wide, and 50 to 300 miles ahead of the cold front. The whole squall zone can seldom be recognised for more than 24 hours, but may move several hundred miles while separate lines of storms form and dissipate, with life periods varying from less than two to many hours. Intense lines may split, adjacent lines merge, and isolated storms move into line, but storm cells generally form and dissipate along a given line.

On 1 July, 1952, the storm cells which moved across north central England were in lines, the first of which was the most vigorous in Derbyshire and Nottinghamshire, though not in some other areas. This instability line was in existence for several hours, but was not followed in detail beyond northern Nottinghamshire. Other, less well-formed storm lines followed it. Two of these have been traced, one following the instability line across central and north Derbyshire, north Nottinghamshire and south Yorkshire two and a half hours later, and a second crossing the southern Pennines between 0300 and 0400 G.M.T. 2 July. At Sale, Cheshire, the instability line was the weakest, but at Stockport it was the strongest. In north-east Staffordshire less than half the day's rainfall was associated with the instability line, and in central north Derbyshire and the west Manchester area about two-thirds. In south Lancashire the instability line contributed only a small fraction.

The forward running of cold air aloft ahead of surface cold fronts is especially effective in leading to thunderstorms when a moist warm surface tongue of air moves north behind a north-moving warm front, for this favours the increasing eastward component in the upper wind which carries cold air across the warm surface axis(9). The warm axis is displaced forward at each higher level: cooling begins aloft as it passes, and instability is realised where the lapse rate becomes critical along a line which is generally oriented a little clockwise of the cold surface front, because advection of cold air tends to be more rapid in the 4north. Ahead of the cold front both temperature and humidity must be high, and this is favoured by free low-level advection of warm air from the south, and by a stable layer or inversion in the warm air which allows a sustained increase of temperature by insolation and of humidity by evapotranspiration. Comparison of this ideal pre-cold frontal situation with the example of 1 July 1952 shows that although the latter was complicated by the upper cold pool, for example in its alignments, all the essential conditions were satisfied. Surface temperatures reached 85 to 90 degrees F widely over southern and eastern England, and dew points exceeding 70 degrees F at 1800 G.M.T. in parts of the north Midlands denote exceptionally high humidity (Fig. 2 D).

The synoptic situations which most favour instability lines in the United States and Britain respectively differ on account of geographical circumstances. The physique of the United States particularly favours the development of pre-cold frontal squall lines because the extensive low Mississippi basin is open to a plentiful supply of warm moist air from the Gulf of Mexico, while the Rockies intercept low-level air masses, and encourage a northward flow of maritime tropical air, and a southward flow of cold air in the lowest few thousand feet. A cold front crossing the western plateaux may become an upper front riding over north-moving tropical air, a surface front being re-formed behind, and thunderstorms breaking out along the upper discontinuity(10).

In Britain, too, no orographic barrier hampers a surface flow of warm air from the south, and cold fronts normally approach from the west, but strong pre-frontal squall lines are less common and more fragmented than in the United States because a special combination of synoptic circumstances is required on account of the geographical setting of the country. North-moving warm fronts are much less common, and, in the absence of a long, high mountain barrier in the west, simple over-riding by a cold front is unlikely. Further, there is no European analogue of the Caribbean Sea. A direct current of moist tropical maritime air entering Britain from south or south-west lacks the requisite high temperature, while a straight or anticylonically curved air stream heated over the continent is derived from too dry a source. The necessary combination of heat and moisture can best be achieved in summer when moist Atlantic air from the latitude of the Azores is heated while travelling over south-west Europe round a centre of low pressure in the Biscay area. When such air enters England from the south-east it may be nearly as warm and moist as Gulf air in the central United States; and when, as on 1 July, 1952, it is transgressed by cold air aloft in the afternoon, the conditions are auspicious for the development of severe instability lines, especially in south-east England, and the south and north-west Midlands.

However cold the advected upper air, it, too, must be moist if violent thunderstorms are to form. The moist upper tongue which leads to

thunderstorms in the Middle West is often produced by extensive convection over Mexico and the south-west United States, and subsequently curves anticyclonically across the country([11]). In the eastern Atlantic moist upper cold pools in summer are commonly formed by the isolation of cold air at the southern ends of large slow-moving upper cold troughs, assisted by anticyclonic development across them([12]). The relevant upper charts show that this took place in the last week of June, 1952. In the Spain-Azores area the upper cold pool is often associated with a slow-moving surface Low, which in the case under discussion appears to have been of independent Mediterranean origin. Both the surface Low and the upper cold pool moved north as the European High receded, and by their interaction eventually caused the intense thunder rains in England.

The Storm Pattern in the North Midlands

We now turn to a more detailed analysis of the storm in the north Midlands (Figs. 5 and 6), with the object of identifying any topographic influence revealed by its pattern. In many places several separate falls contributed to the day's rainfall total, but a zone about 15 miles wide in Derbyshire and Nottinghamshire (Fig. 5) suffered only a single evening storm—the instability line—a narrow wave of precipitation unbroken along its length, whose onset was generally marked by a squall and pressure jump. Attention is confined to this zone.

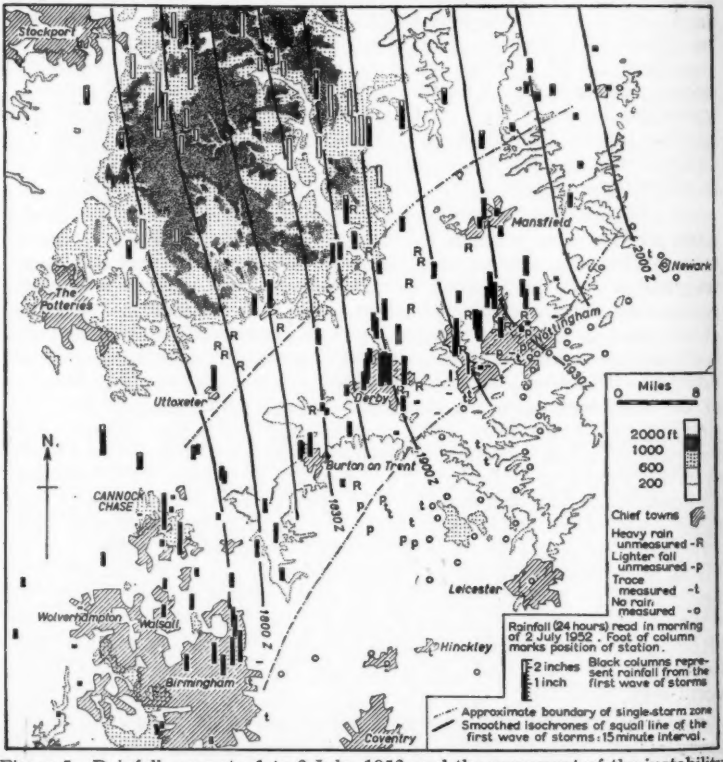

Figure 5—Rainfall amounts, 1 to 2 July, 1952, and the movement of the instability line on 1 July.

From times of onset of rain, squalls and pressure jump, smoothed isochronous lines have been drawn (Fig. 5) which indicate that the squall front moved east-by-north at a speed which increased from about 15 m.p.h. at 1745 G.M.T. to 25 m.p.h. at 2000 G.M.T., although the component of the general wind normal to the line could not have exceeded 10 m.p.h. Before 1745, and further west, the thundery outbreaks were more irregular. The heaviest single falls were recorded near the south-east boundary of the heavy rain belt, where the warm air was at its moistest, and where the thunderstorm cells had no near neighbours on the south side competing for indraught air (Figs. 2 and 4). The boundary of the heavy rain area was sharp; for example, near Derby, the lower Erewash valley and Nottingham falls of 1.7 to 2 inches occurred only 3 miles from places which received less than 0.01 inches There were, however, a few scattered light falls to the south-east. probably from weak high-level storms associated with a strong afternoon isallobaric trough (Fig. 2 E), which may have served to produce the belt of high dew points shown in Figure 2 D through evaporation of rain.

Identification and Location of Cells

The storm pattern in the "single storm zone" was reconstructed from descriptive data derived from many sources(13) in conjunction with rainfall and other measurements. The duration of rainfall varied little, despite its irregular distribution. Autographic and eye observations show that rain fell for 30 to 35 minutes in the Derby-Nottingham area, with most of the fall at each station concentrated in the first 15 to 20 minutes, followed by much less intense rain. For example, at several points in Derby over 1.8 inches fell in 30 minutes, but nearly all in the first 17 minutes; at Ilkeston over 1.7 inches in 35 minutes, nearly all in the first 15 to 18; and at Strelley, west of Nottingham, 1.8 inches in 30 minutes, nearly all in the first 15 minutes. A fall of 1.7 inches in 20 minutes is "very rare," and each of these cases falls into that category.

The time distribution shows that most places were affected by a single thunderstorm cell, and that a line of contiguous cells moved east-by-north as a unit. The various rainfall maxima of Figure 6 may be taken to correspond to individual cells. The unit cells of middle latitude thunderstorms each have a life period of about 1½ hours(14). For the first 30 or 40 minutes all flow is upwards, no rain falls and surface temperature is little affected. This is the stage in which topographic influence on thunderstorm initiation is to be sought. A local upward acceleration initiates horizontal divergence aloft, and a slight fall of pressure over an area up to 6 or 8 miles across, into which the surface winds gently turn, and within which the thunder cloud grows (15). Eventually the increasing viscous drag of precipitation in the cloud overcomes the updraught, and a vigorous downdraught brings heavy rain or hail suddenly to the ground in a core of dense air, chilled by evaporation of rain. Maintained by falling rain the downdraught spreads throughout the mature cell, and, impinging on the ground, is forced to spread outwards, carrying with it a marked fall of temperature, rise of pressure and squalls of wind. It undercuts the warm air around as though it were a miniature cold front. Rain is heavy for 5 to 15 minutes and then decreases; and after 15 to 30 minutes the senile stage, lasting for a further 30 minutes, sees a gradual break-up and contraction of the rain area and eventual cessation of rain.

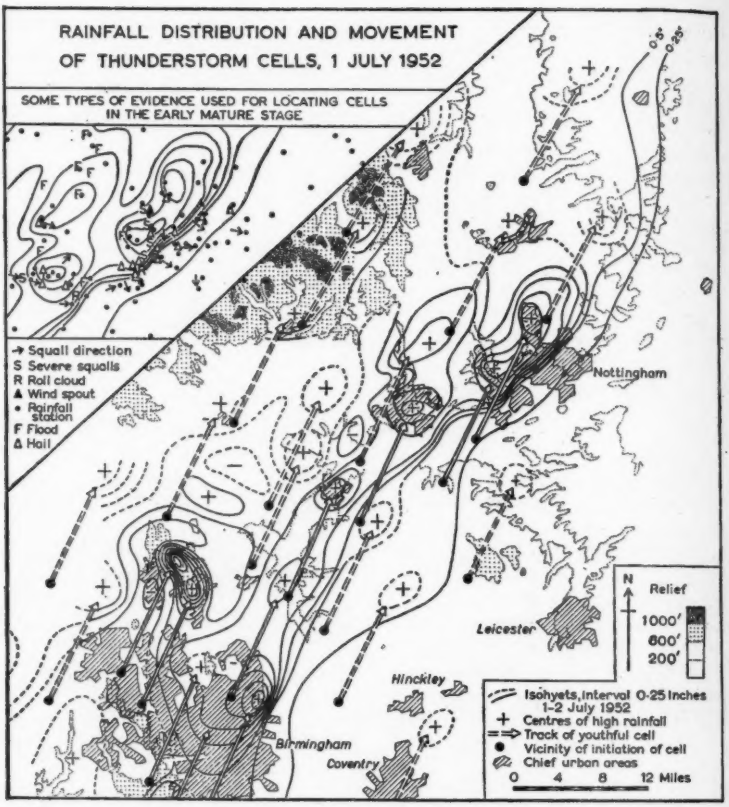

Figure 6

This description applies to an ideal, isolated and stationary cell, but real thunderstorms usually comprise a number of contiguous moving cells in different stages of development. In moving cells almost all the downdraught spreads forward, and if the cells are in line, and if several are simultaneously mature, their combined downdraughts transport to the surface a great volume of chilled air with a pseudo-frontal leading edge. Since lateral spread is inhibited by collision of downdraughts, the forward flow is further strengthened, and a long, more or less connected squall line is formed, often with the typical roll cloud, and local winds of destructive violence. Ahead of it, in the warm air, is a pressure trough, and behind it an asymmetrical pressure ridge, the 'thunderstorm High' (Fig. 4), due to the cold air([16]). Where the squall line does not become involved in developing cells it may travel out beyond the rain area with a narrowing band of high winds and a temperature and pressure discontinuity which can be followed up to 20 miles from the nearest cells. For example, on 1 July, 1952, the temperature at Ruddington, 5 miles from the rain, fell by 10 degrees F in a few minutes, and later, at Syerston, 6 miles outside the

belt of rain where it was not very intense, there was a sudden fall of 2.5 degrees F at the time of a pressure jump.

Scattered observations of various phenomena can be interpreted in the light of these generalisations to reconstruct the dynamic pattern of the storm of 1 July, 1952 (Fig. 6). Large intense rain falls are assumed to indicate cells in the mature stage, the centre of maximum rainfall probably marking the position of the forward central part of a cell in middle maturity. Hail usually falls mainly in early to middle maturity, and is therefore expected up-wind of the maximum rainfall. For example, in Wollaton and Aspley (west Nottingham) windows were broken and glasshouses damaged by large hailstones, the largest of which were measured at 2½ by 1½ by 1 inch; this is taken to indicate a cell in early maturity, and away from it hail decreased in size and amount although rainfall amounts and durations increased north-north-eastwards, that is, down-wind. Destructive winds occur just within the leading edge of the downdraught dome in early or early-middle maturity, and often coincide with or follow large hail. Trees were broken and uprooted, for example, near Littleover and Mickleover, west of Derby, and near Stapleford and south of Strelley, but squall winds were much less violent away from cells in early-middle maturity. The direction of flow of downdraught air, often indicated by low scud, was down the pressure gradient, forward and outward from the positions of mature cell centres located by other data. There is no normal frontal wind veer in this type of storm. In the Derby-Nottingham area light variable winds well ahead of the storm belt settled down to light east to south-east in the pressure trough in the warm air, and after the sudden high squalls with heavy rain the wind decreased quickly, and took up directions varying from west-north-west to north-north-east along the pressure gradient in the following cold-air ridge. The onset of downdraught squalls should be shortly followed by the appearance of the characteristic roll cloud of the squall line, produced at the front of the cold dome as it over-runs heated surface air, and moving out from the forward central part of the cell in the direction in which the line moves. Some graphic accounts of the first formation of the roll cloud at several places have given further guidance in locating mature cells. Descriptive observations of many kinds have thus been used in conjunction with timed measurements of temperature, pressure change and rainfall to locate positions of mature cells, from which, by extrapolation, the locations of cell initiation may be approximately deduced([17]).

Propagation Along the Storm Line

The instability line moved east-by-north while tending to accelerate. The dense black cumulonimbus clouds, probably extending up to near the tropopause at 38,000 feet, all moved steadily north-north-east, and were clearly distinguishable from the very low scud, yellowed by dust swept up by the squalls, which travelled eastwards at high speed. These differences in direction reflect the fact that the motion of a persistent instability line is made up of two chief elements—the movement of the component cells with the air currents in which they are embedded, and forward propagation by the growth of new cells. Cells tend to move with the vector mean wind between 2,000 and 20,000 feet—here about south-south-west—but slightly slower([18]). This element of motion is virtually independent of surface features([19]) but topography may influence the

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movement of the line through propagation. By inducing irregular initiation of cells apart from an existing line it may act as a disruptive influence, competing with those other factors independent of the surface which tend to keep new cells in line.

Most new cells develop near older ones, partly because nearly saturated air may be entrained there in a growing cloud, but mainly because the downdraught dome, while it is still steep in the first 15 or 20 minutes of its existence, forces up the warm air around it. It has been found statistically([20]) that new cells form most readily between two existing closely adjacent cells whose cold outflows collide. The next most favoured position is immediately in front of existing cells, within about 3 miles, although further forward the surface of the downdraught is too flat. Thus, if cells initially develop roughly in line, such a line consolidates by lateral propagation, and moves forward bodily by propagation just ahead of it.

On 1 July, 1952, in the north Midlands large clouds would move about 9 miles on the upper winds during the youthful phase of 20 to 30 minutes. A backward, that is, south-south-west, displacement of 9 miles from early mature cells should therefore indicate the approximate areas of initiation of cells (Fig. 6). In the southern part of the zone traversed by the instability line new cells appear to have originated mainly in the favoured places near mature cells. In the Birmingham area, however, before the instability line was clearly formed, the ridge of high ground in the south of the city seems to have been the scene of initiation of several new cells. Others originated over broken surfaces near the Trent vale, and joined the line. Thus meteorological factors mainly controlled propagation in this south-eastern zone of the rain area, but there is some indication of topographic influence.

Surface features may help new cell formation by causing local uplift through either relief or varying thermal properties. Relief can act in three chief ways. Convectively unstable air crossing hills may realise its potential instability through uplift : or some of the perturbations caused by rough terrain may trigger cumulus formation in convectively unstable air : or, thirdly, and especially in summer, hills may act as high-level heat sources, being warmer than the free air at the same height. A radar investigation in an area of moderate relief in Ohio([21]) suggested that the second mechanism is most important when storms move briskly, and that the commonly-held belief that thunderstorms follow rivers may be due to propagation favoured by bluffs and relatively deep tributary dissection near the main streams. The evidence of Figure 6 is an insufficient basis for useful comment on these possibilities.

Instability lines are best developed and most persistent in relatively featureless country, tending to disintegrate where strong relief rapidly breaks up the downdraught, and favours irregular propagation([22]). Charts drawn by the writer from data published by Williams in the United States([23]) show that strong guidance by only moderate relief occurs mainly after the cold dome has flattened too much to initiate cell growth. The advance of the 1952 instability line over the Pennines appears to have been less regular, and its squalls less violent than over the smoother country to the south, where relief was insufficient to cause serious disruption by irregular propagation.

On quiet, hot days, local surface temperature contrasts may lead to local areas of convergence, favouring thunderstorm formation(24). Kratzer(25) suggested that large cities may influence convectional rainfall through a thermal mechanism, and a casual inspection of Figure 6 suggests such a correlation. This would relate not to initiation, but to some influence on the course of development of mature cells initiated 10 or 12 miles from the rainfall maxima. City air on hot evenings may be considerably warmer than that in the surrounding countryside(26). For example, at 1900 G.M.T. on 1 July, 1952, the temperature near the centre of Derby was 80.9 degrees F compared with 78.8 nearer the suburbs, and 75 at Chellaston and Thulston in the Trent vale nearby. Such differences causing gentle convergence might invigorate the updraughts in mature cells, accelerating the "turnover" and intensifying the rainfall, or they might prolong the mature stage and increase the total rainfall from the cell. But neither possibility is proved, and possible reasons have already been advanced for the exceptional rainfalls from the southernmost cells of the rain belt, which may have coincided with the middle Trent towns fortuitously. Convergence into city areas may well favour initiation of new cells, but the sites of these towns are such that the effect of relief could not be readily distinguished from the thermal effect, the rainfall maxima on this occasion would have been 10 or 12 miles away, and in most cases the meteorological mechanism of spontaneous propagation would have obscured any effect of the surface.

While the geographer is tempted to look for single surface factors favouring thunderstorm formation, no conclusive correlation can emerge from the study of a single storm. The only positive conclusion from this analysis is that there appeared to be a limiting degree of relief below which the surface form was ineffective in controlling the movement of the instability line, and even this is very tentative on account of the sparsity of information from the upland areas.

Vortices and Tornadoes

In the United States the same synoptic circumstances favour instability lines and tornadoes, and a vigorous wind spout or small tornado reported from Kimberley, west of Nottingham, was entirely in keeping with the character of the storm.

The downdraught producing the squall line is undulating in both plan and section parallel to the line. The long pressure dome has a peak under each cell (27), and a strong, sustained downdraught adjacent to a weaker one causes a bulge on the leading edge of the cold air, and a wave-like perturbation on its upper surface (28). This is contained in a small area of low pressure under a large, but not yet precipitating cumulus cloud, and within it cyclonic wind shear can lead to exceptional vorticity, enhanced by the very strong convergence as the cold air rushes down the pressure gradient. Such enclaves along a squall line, containing very warm and humid surface air (29) partly surrounded by rain and hail, form a highly favourable environment for the growth of tornadoes and wind spouts.

On 1 July, 1952, there were many reports of high dust spirals and small "whirlwinds" in the warm air, for example, at Chaddesdon, Sandiacre and Stoke Bardolph. Cloud spirals were also seen, for example, over Stapleford; and looking west from Kimberley church "a number of clouds of greyish-white were being whirled round and

upwards in spirals; this increased until it looked as though the sky was boiling." This irregular small-scale vorticity in the warm air, probably induced by the irregular gustiness of the downdraught squalls (30), appears to have culminated at Kimberley in a salient or cut-off of warm surface air. A number of large ash trees along a narrow track aligned about south-west to north-east were uprooted and thrown north-north-east and others were stripped of their branches, though nearby trees were undamaged. Two isolated ash trees weighing several tons, south of the railway near Awsworth Junction (Kimberley) were carried about 120 feet on to the embanked railway tracks, dislocating communications. Four other trees north of the railway were similarly moved. It is significant that the damage occurred in a lull, with a lightening sky, between two distinct maxima of precipitation, and was followed immediately by hail—an unusual sequence in this storm zone.

Conclusion

The exceptionally intense thunder rains of 1 July, 1952, irregularly distributed in a belt across the north Midlands, were associated with the passage of a very vigorous instability line, similar in character to those that bring to the central United States most of its summer thunderstorms and tornadoes. The line developed between the Birmingham and Manchester areas in synoptic conditions which were unusually favourable for this particular form of convective activity. It has been possible, by examining rainfall distribution and various supplementary data in relation to the ideal sequence of thunderstorm cell development, to reconstruct the dynamic pattern of the storm over limited areas, but no simple relationship between surface features and the rainfall pattern could be thereby established. The association of patches of maximum rainfall with the largest towns of the middle Trent area may have been coincidental. "Spontaneous propagation" induced by the dome of downdraught air seems to have been the chief method of initiation of new cells along the instability line.

While the synoptic circumstances were a remarkably favourable combination such as can be expected perhaps no oftener than once in a decade or more, nevertheless this storm exemplifies that type of thunderstorm activity that breaks out in a less extreme form ahead of cold fronts much more frequently, and it may therefore be regarded as a type example of a not unimportant element in the dynamic climatology of the English Midlands.

NOTES

(1) F. A. Barnes and H. R. Potter, A flash flood in western Derbyshire, *East Midland Geographer*, 10 (1958) 3.

(2) For statistical equivalents of this classification see *British Rainfall 1949*, (1951) 33.

(3) Synoptic data were taken from the *Daily Weather Report* and *Daily Aerological Record* published by the Meteorological Office, London.

(4) Figure 2 was drawn in part from data in *Research Publication 52/1*, Thunderstorm Census Organisation.

(5) The detailed surface charts were drawn from actuals supplied by courtesy of W. J. Grassick.

(6) C. S. Durst and R. C. Sutcliffe, The importance of vertical motion in the development of tropical revolving storms, *Quart. J. R. Met. Soc.*, 64 (1938) 75. H. Solberg, Le mouvement d'inertie de l'atmosphere stable, et son role dans le theorie des cyclones, *P. V. Meteor. Un. Geod., Geophys. Int., Edimbourg 1936*, II, 66.

(7) M. J. ANDRE, Distribution of instability weather types with respect to summer cold fronts in the United States, *Bull. Amer. Met. Soc.* 30 (1949) 228.
In 1943 at Chicago not a single thunderstorm occurred on a cold front proper. see
L. L. MEANS, On thunderstorm forecasting in the central United States, *Mon. Weath. Rev*, 80 (1952) 165.
In the Wilmington, Ohio area in the summer of 1947, when lines of thunderstorms were distinguished by radar on 32 out of 56 days with thunderstorms, they were frontal on only 6 days ; see
H. R. BYERS, Thunderstorms, in *Compendium of Meteorology*, ed. T. E. MALONE; Amer. Meteor. Soc. (1951) 967.

(8) H. T. HARRISON and W. K. ORENDORF, Pre-cold frontal squall lines, *United Air Lines Meteor. Dept.*, Circ. No. 16 (1941)

(9) C. K. M. DOUGLAS, Some aspects of surfaces of discontinuity, *Quart. J. R. Met. Soc.*, 55 (1929) 123
—Rains from above 6,000 feet, *Quart. J. R. Met. Soc.* 62 (1936) 207.
—The Tibshelf tornado, *Weather*, 7 (1952) 311.

(10) J. R. FULKS, The instability line, *Compendium of Meteorology*, Amer. Meteor, Soc. (1951) 647.

(11) H. WEXLER and J. NAMIAS, Mean monthly isentropic charts and their relation to departures of summer rainfall, *Trans. Amer. Geophys. Un.*, 19 (1938) 164.
A. M. CROCKER, Synoptic applications of the frontal contour chart, *Quart. J. R. Met. Soc.* 75 (1949) 57.

(12) C. V. SMITH, in Cold pools (Report of Met. Office discussion) *Met. Mag.*, 82 (1953) 81.

(13) Much data were derived from correspondence with a large number of the British Rainfall Organisation's observers, and with members of the general public who responded to appeals for information made through local newspapers.

(14) U.S. WEATHER BUREAU, *The Thunderstorm*, (1949), Washington D.C.

(15) W. BLEEKER and M. J. ANDRE, Convective phenomena in the atmosphere, *Journ. Met.* 7 (1950) 195.

(16) W. SCHAFFER, The thunderstorm High, *Bull. Amer. Met. Soc.* 28 (1947) 351
D. T. WILLIAMS, A surface micro-study of squall-line thunderstorms, *Mon. Weath. Rev.* 76 (1948) 239.

(17) The times of temperature and pressure changes were more useful than records of their magnitude, which were normal for a storm of this type. At Stockport the squall brought a rapid surface temperature fall of 18°F. (see F. EDWARDS, in a letter to *Weather* 7 (1952) 291), while there were sudden falls of temperature at all places in the rain belt. These decreased in magnitude eastwards and with time because of the normal diurnal temperature fall : for example, 11° at Ashbourne, 10.9° at Derby, 9.2° at Watnall, 8.2° at Woodthorpe. Humidity did not fall, for there was no front present, and in the Nottingham-Derby area the reduction of surface temperature to the dew point, about 70°F., led to local ground fog and near-saturation for several hours after the storm. The pressure changes in places with intense rain all showed almost instantaneous jumps of 2 to 3 mb. at the arrival of the squall, and often also the short-lived peak of about 1 mb. amplitude associated with the very heavy downdraughts of early-middle maturity.
The lightning, as frequent as 20 strokes a minute or more in many areas, with multiple, 'pearl necklace' and ball discharges, and red and violet coloration, was interesting, but of no help in reconstructing the detailed pattern of the storm.

(18) H. R. BYERS and L. J. BATTAN, Some effects of vertical wind shear on thunderstorm structure, *Bull. Amer. Met. Soc.* 30 (1949) 168.
J. S. MALKUS, Effects of wind shear on some aspects of convection, *Trans. Amer. Geophys. Un.* 30 (1949) 19.

(19) For example, curvature in the intense rain pattern is far less likely to be related to surface features than to the downward transfer of momentum by downdraughts.

(20) *The Thunderstorm* (1949) op cit.

(21) Ibid.

(22) C. HALLENBECK, Squall lines in New Mexico, *Mon. Weath. Rev.* 58 (1930) 402.

(23) D. T. WILLIAMS (1948) op cit.

(24) H. VON FICKER, Uber die Entstehung lokaler Warmegewitter I. Mitteilung, *Sitzungsberichte der Preussischen Akademie der Wissenschaften Physikalisch-Mathematische Klasse*, Berlin (1931) 28.

(25) A. KRATZER, Das Stadtklima, *Die Wissenschaft* Bd. 90, Friedr. Vieweg, Braunschweig (1937).

(26) R. GEIGER (in translation) *The climate near the ground* (1950) Harvard Univ. Press.

(27) W. SCHAFFER (1947) op cit.
F. LOEWE, Cooling by rain as a cause of pressure rise in squalls, *Quart. J. R. Met. Soc.* 73 (1947) 190.

(28) D. T. WILLIAMS (1948) op cit.

(29) The great outbreak of destructive tornadoes in the United States on 21-22 March 1952 occurred along an instability line, with the greatest concentration in the zone of the highest dew points, which were about 70°F.—about the same as in the warm air over the Midlands on 1 July 1952; see J. A. CARR, *Mon. Weath. Rev.* 80 (1952) 50.

(30) C. K. M. DOUGLAS (1952) op cit.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to very many people who supplied descriptions of this storm. Particular thanks are due to Mr. Arnold B. Tinn for discussion, and for his part in helping to collect and collate a large body of information.

POWER STATIONS AND THE RIVER TRENT: A NOTE ON FURTHER DEVELOPMENTS

E. M. RAWSTRON

THE FACTS

Every year more and more new generating plant is coming into service on the banks of the River Trent. In an earlier note(1) attention was drawn to the vast expansion that had then begun. The size of the expansion was, however, considerably underestimated to 1970 and thus a review of progress to date and a revised statement of plans for the future now seem necessary.

Before the war there were but two stations on the river between Burton-upon-Trent and the Humber, a small one at Burton itself and a station of medium size at Nottingham. To these two, the latter of which is now four times bigger than it was in 1939, have been added seven much larger stations, and consent is at present being sought to begin work on two further huge stations. Sites for two others are under examination and the position may be summarised as follows: in 1939 installed capacity was 118,500 kW; at the end of March 1960, 2,806,500 kW; by 1970 there will be between 8,500,000 and 9,000,00 kW, and by 1975 perhaps as much as 12,000,000 or 13,000,000 kW. The figure for 1970 is about 50 per cent. greater than the estimate given in the earlier note. Details of developments to date and plans for the future are listed in Table 1.

TABLE 1

Station	*Installed capacity at 31st March, 1960 (Kilowatts)*	*Capacity under construction or planned (Kilowatts)*
Burton-on-Trent	43,500	nil
Castle Donington	627,000	nil
Cottam	(site under consideration)	
Drakelow A	244,000	nil
Drakelow B	240,000	240,000
Drakelow C	nil	700,000
High Marnham	200,000	800,000
Holme Pierrepont	(consent being sought)	2,000,000
Keadby	360,000	nil
Nottingham	316,000	nil
Ratcliffe-on-Soar	(site under consideration)	
Staythorpe A	360,000	nil
Staythorpe B	nil	360,000
West Burton	(consent being sought)	2,000,000
Willington A	416,000	nil
Willington B	nil	400,000
	2,806,500	6,500,000

THE FACTORS

Notwithstanding the advent of nuclear power, the need and basic reason for the construction of this chain of huge stations on the Trent still remain the same. The need arises because the demand for electricity continues to increase annually at about 7% (compound). The reason

for the prominence of sites along the middle and lower Trent valley is that electricity can be generated more cheaply in the East Midlands than elsewhere.

The cost of marketing current is the largest item in the costs of production of the industry as a whole. The Trent valley is advantageously situated in relation to the national market, whose core comprises three major features: (1) the very dense concentration of Greater London; (2) the curved zone of cities and towns forming the "Central Urban Region," which extends from the West Midland Conurbation via Leicester, Sheffield, Leeds and Manchester to Liverpool, and (3) the much less dense, but even spread of towns and rural settlements in the rest of Lowland England. Other things being equal the distribution of electricity generating stations would closely reflect the distribution of towns, as in large measure it does and will continue to do, and no apparent anomaly such as the Trent valley chain of stations would exist. But other factors than mere centrality to the national demand, which is an insufficient factor in itself, are playing their part. Chief among these is the price and availability of coal, which is the second largest item in costs of production, making up over 60 per cent. of works costs. The cheapest coal in the greatest quantity is to-day to be found in the East Midlands and Yorkshire coalfields. These facts make electricity generation cheaper near those coalfields than elsewhere; and, provided the power stations built there work at the highest possible rate of output, total production costs (including costs of marketing the current in London, Lancashire and other coal deficit or high cost coalfield areas) are also less. The advent of nuclear power stations, which likewise need to work on base load, may have cast some doubt on whether the Trent valley stations could maintain a high enough load factor to overcome the diseconomy of distance from major markets. But this doubt is dispelled for the time being at least for three reasons. First, the nuclear power programme has been slowed down. Second, the demand for electricity rises so quickly, accompanied by greater technical progress than was predicted in 1950 in generation at conventional power stations, that a lower load factor is now acceptable at Trent-side stations than was thought feasible only a few years ago. Third, there is now a glut of small coal which was not foreseen as recently as 1956/57.

Given the space-relationships of cheap coal to national market, all that remains is to find places that satisfy the siting requirements of stations. The need for cooling water, either with or without the use of cooling towers, is best met on the Trent in the East Midlands and on certain rivers in Yorkshire. As far as possible cooling towers should be dispensed with by spacing stations at appropriate intervals along the river and by keeping the size of each station within the capacity of the river to supply it with water for direct cooling. Capital costs are thus reduced. But the demand for electricity has now outstrippped the meagre inland sources of water supply and thus even on the Trent cooling towers are needed at most stations for part at least of the generating capacity installed. Only Nottingham, Staythorpe 'A' and Keadby manage entirely without the use of cooling towers. Most of the others, built or now building, will depend increasingly on cooling towers, the largest stations virtually entirely so; and the closer spacing of stations in the future may have its effect on those at present reliant

wholly on direct cooling. Concrete cooling towers at Nottingham would hardly add beauty to the view from Nottingham Castle Rock, though, in truth, they would do little to mar it. But the electricity authorities seem to have decided that further disfigurement of the skyline can readily be avoided at Nottingham by providing a generous allocation of cooling towers for stations further upstream in order to keep the temperature of the Trent at Nottingham within the appropriate limits. They have decided also not to expand generating capacity at Nottingham for the time being. When the older plant at Nottingham becomes due for renewal, however, its replacement in the same space by generators with a greater output may necessitate the reappraisal of cooling methods there.

The exact choice of sites along the river is determined, apart from the need to space out the stations, by reference to land values and access for coal transport. The former implies simply the avoidance of built-up areas. The latter means proximity to railway lines linking the collieries to the river. Post-war stations are sited, therefore, outside the built-up areas at points where railways from the coalfields cross or come up to the river (Fig. 1). There are no exceptions to this rule as was shown in the earlier note on this topic(2). Furthermore, the converse of the rule is soon likely to be true, *viz.*, that wherever railways from the coalfields cross or come up to the river outside built-up areas, power stations will be found. The prospective sites at West Burton (near Gainsborough) and Cottam, when used, will leave vacant only one further site (Stockwith/Misterton) between Newark and the Humber if spacing and rail access continue to be important factors. Similarly the use of Holme Pierrepont (across the river from Colwick marshalling yards) and Ratcliffe-on-Soar (south of Trent Junction) leaves "few pickings" between Burton and Newark unless much closer spacing with the universal use of cooling towers is forced on the electricity authorities by the ever rising demand for current.

Holme Pierrepont and Ratcliffe

It is appropriate now to comment upon the late choice of the prospective sites at Holme Pierrepont and Ratcliffe. The most obvious sites in the whole of the Trent valley are respectively near Trent Junction and Colwick marshalling yards. These are the points through which the greatest volumes of coal have always left the Nottinghamshire and Derbyshire coalfield and they coincide with crossings of the river. Holme Pierrepont and Ratcliffe correspond to the stations that might well have been built at either of these places forty years ago, had the course of economic history been otherwise. The Trent Junction/Ratcliffe site was recommended by consultant engineers in 1919 as the best site for a station to supply the whole of the central East Midlands(3). It was turned down by the county boroughs, who commissioned the advice, on grounds of cost. A second report advised each borough to establish its own station and recommended for Nottingham the site at North Wilford. It is the use of this latter site, by determining the spacing arrangement of subsequent stations, that has until now been the stumbling block, hindering the use of sites near Trent Junction and Colwick.

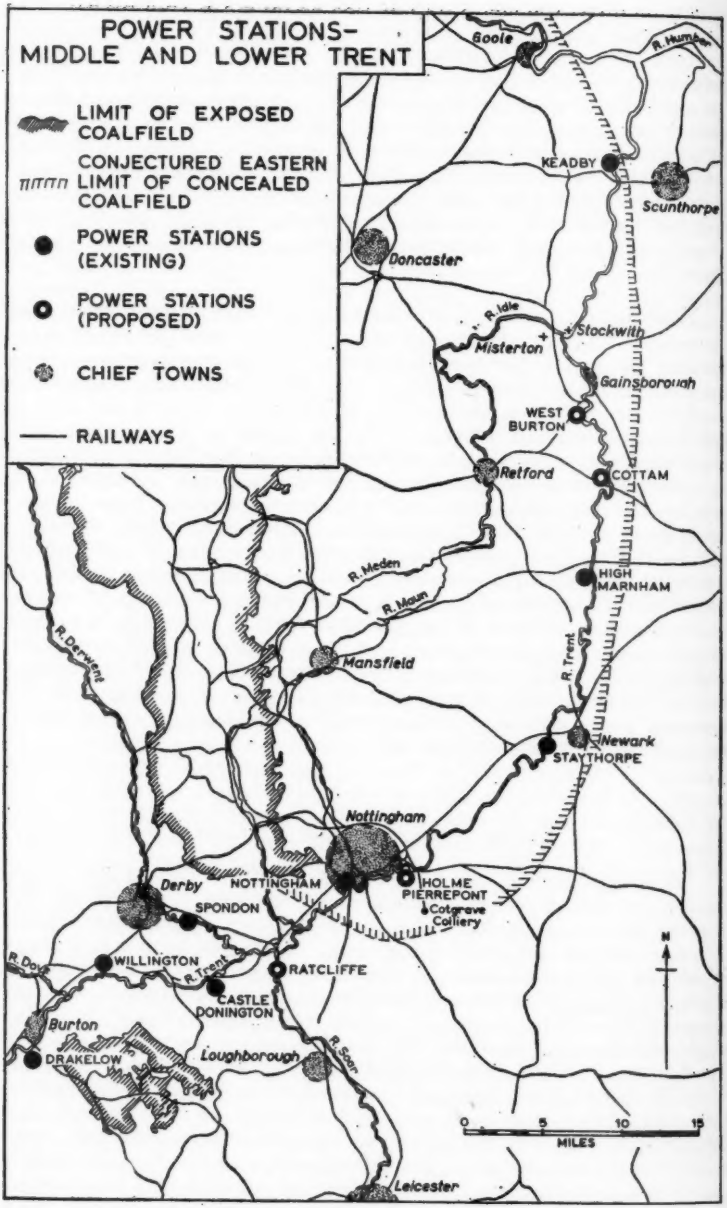
POWER STATIONS–
MIDDLE AND LOWER TRENT
LIMIT OF EXPOSED COALFIELD
CONJECTURED EASTERN LIMIT OF CONCEALED COALFIELD
POWER STATIONS (EXISTING)
POWER STATIONS (PROPOSED)
CHIEF TOWNS
RAILWAYS
Goole
R. Humber
KEADBY
Scunthorpe
Doncaster
R. Idle
Misterton
Stockwith
Gainsborough
WEST BURTON
Retford
COTTAM
R. Meden
R. Maun
HIGH MARNHAM
R. Derwent
Mansfield
R. Trent
Newark
STAYTHORPE
Nottingham
Derby
NOTTINGHAM
SPONDON
HOLME PIERREPONT
Cotgrave Colliery
R. Dove
WILLINGTON
R. Trent
RATCLIFFE
CASTLE DONINGTON
Burton
DRAKELOW
Loughborough
R. Soar
N
0 5 10 15
MILES
Leicester

Figure 1

But that was not the end of the story. As early as about 1911, the Derbyshire and Nottinghamshire Power Company had taken an option on a site at Colwick with a view to its being used by a power station from which to develop a supply system serving the eastern part of their virtually undeveloped supply area. They provided current only to Ilkeston and adacent districts at the time. Their scheme depended for its success, however, on being able to supply the whole of the city of Nottingham, too. In 1922 a legal battle ensued between the City Corporation and the Power Company as to the respective merits of North Wilford and Colwick (Holme Pierrepont). The Corporation, being the more powerful authority at the time, won. The Power Company thereupon gave up their option, bought Spondon Power Station forthwith from the predecessors of the rayon firm of British Celanese, and accordingly developed the western part of their area first. In the light of history the City Council of the early 1920's must ultimately be held to blame if cooling towers are eventually erected at Nottingham. Indeed, with the wisdom of hindsight, one can affirm that the Nottingham power station at North Wilford has proved a mistake with regard to both the townscape of the city and the efficient location of power production on the banks of the Trent. But who was to know this in 1920? This story illustrates the point of contact between economic history and economic geography. To explain fully the pattern of power stations along the Trent, the spatial-economic relationships are not enough : the detail of the pattern depends also on a political-economic struggle among personalities in the past.

Holme Pierrepont, which is to use coal from the new colliery at Cotgrave as well as from other mines to the north, will be one of the largest in the world. With its twin station on the lower Trent at West Burton, it will be the largest in Britain, at least for a time, and probably the biggest in Europe outside the Soviet Union. Four generators, each of 500,000 kW capacity are to be installed at Holme Pierrepont compared with a total capacity at Nottingham of 316,000 kW in several generators. The station building itself will, however, probably be little larger. These great contrasts have been made possible by the rapid advance in generator design since the end of the war, when the biggest generating set in Britain had a capacity of only 100,000 kW.

For the time being, the Trent valley is the cheapest location for electricity production in Britain. Still lower costs than elsewhere would result for a time if the National Coal Board disposed of its large stocks of small coal and slack at cut prices. At least, if the National Coal Board is not prepared to do that, the Board will doubtless make sure that any fall in oil prices is countered by a corresponding fall in the price of coal for power stations. Rapid progress in the design of nuclear power plant now seems the only development capable of halting the construction of stations on the Trent before the limit of saturation is reached. At present, progress is not rapid enough for any check to take place and the date when nuclear power will exceed conventional power in total output must be put back from 1980 to at least 1990 or even 2000 A.D.

(EDITORS' NOTE : At the time of going to press a public enquiry is being held at Nottingham to hear objections to the proposal to build a power station at Holme Pierrepont. It appears that if the proposal is approved, consent will be sought later for a second station, also of 2,000,000 kilowatts, to be built on the same site. It is hoped to include a note on this matter in the East Midland Geographer for June, 1961.)

NOTES

(1) E. M. RAWSTRON, Power stations and the River Trent, *East Midland Geographer*, 2 (Dec. 1954) 23-30.

(2) Ibid., Fig. 3, p.28.

(3) J. H. RIDER and C. H. WORDINGHAM, *Report on electricity supply in the East Midlands District*, Westminster, 1919. (For private circulation among the parties concerned.)

THE CHURNET VALLEY

C. A. M. King.

The middle Churnet valley is one of the longest and most characteristic glacial overflow channels of the Southern Pennines. At the maximum of the Irish Sea Ice advance, ice was banked up against the flanks of the south-western Pennines, ponding back the water draining from the hills. This water, in escaping, cut numerous overflow channels which, on the retreat of the ice sheet, caused interesting drainage changes. Many of the channels and lakes have been described by Jowett and Charlesworth (1929) and mentioned by several other authors. The present contribution attempts to describe in rather more detail the Churnet valley overflow, pointing out the drainage changes to which it has given rise and attempting to reconstruct the pre-glacial surface, from which the former stream courses and watersheds can be deduced. This enables the extent of the reversal of drainage in this valley to be estimated.

The Geological Background

The Churnet river flows over a wide variety of Carboniferous and Triassic outcrops, in an area where the geological history has been complex. The river rises on the flanks of the Derbyshire Dome, formed of Carboniferous rocks, and bounded to the south-west by the complex pitching syncline of the Potteries coalfield. The converging outcrops of Millstone Grit, of which only the broader eastern one affects the Churnet, indicate the position of this syncline. The outcrops converge at the Cloud (Fig. 1). The high ground of the Roaches and Hen Cloud to the east is also formed of Millstone Grit. The Upper Churnet flows south-west between Hen Cloud and the ridge of Morridge, which is formed of one of the harder grits within the underlying Limestone Shales. The Carboniferous Limestone at the base of the series does not directly affect the Churnet valley, which in its lower course flows over Triassic strata. The centre of the syncline is occupied by the Middle Coal Measures Series to the west of the Churnet valley, and it is here that the head streams of the Trent rise, north-east of Tunstall. A tongue of Coal Measures forms the relatively low ground south of Leek, occupied by a small stream flowing north to Horse Bridge (960535). A larger outcrop, further south-east, extends between Ipstones (500022) in the north. Oakamoor (052448) in the east, and Dilhorne (970433) in the south-west: the Churnet now flows across the north-east part of this outcrop. Of the Carboniferous strata the harder bands of the Millstone Grit and some of the grits of the Limestone Shales are the most resistant and form the most conspicuous relief features.

The Triassic rocks, deposited on an uneven surface of Carboniferous strata, outcrop now as a belt to the south and west of the Derbyshire Dome. To the south they are banked up against a steep slope of limestone, which outcrops in the Weaver Hills, and from the evidence of Trias-filled potholes near Cauldon Low (Kent, 1957) it seems likely that they once covered a wider area than their present outcrop. Elsewhere the Lower Triassic Bunter Sandstone appears to fill valleys cut by streams draining the higher land, which at the time of deposition lay to the north. One such infilled valley is now occupied by the Churnet

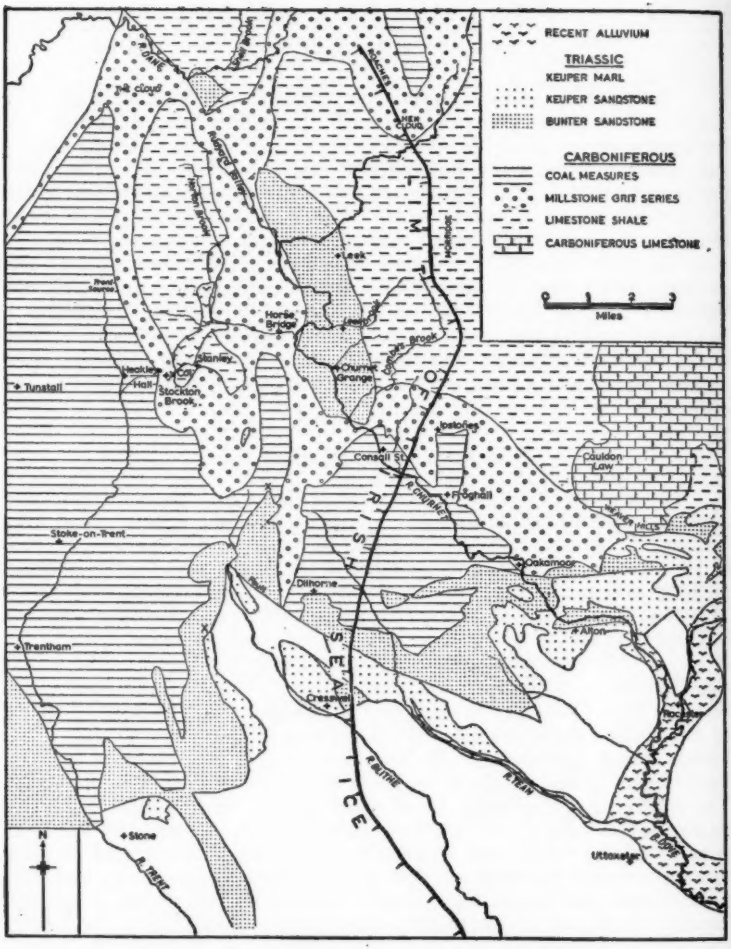

Figure 1—The geology of the Churnet valley and surrounding area.
The main drainage lines and the limit of the Irish Sea Ice sheet at its stage of maximum advance are shown.

in the neighbourhood of Leek, where an elongated outlier of Trias is found. South-east from Oakamoor, too, the Churnet flows over Triassic rocks, which include the Bunter and Keuper Sandstones and the Keuper Marl. The last is not reached till about one mile upstream of Rocester, where the Churnet flows into the Dove. In places these rocks are massive, and near Alton (071425) in particular steep cliffs are developed in the Bunter Sandstone, which makes the Churnet gorge in this area an impressive feature. The structure of the Triassic rocks shows that considerable earth movements have taken place since they were deposited, probably during the Alpine orogeny. This movement is revealed in the

faults which frequently displace both Carboniferous and Triassic rocks, movement having been initiated in pre-Triassic times, but renewed in the Tertiary. One such fault runs east to west near Oakamoor. Figure 1 shows the geology of the area.

Denudation and Drainage

The development of erosion surfaces and the associated drainage pattern are relevant to this discussion as the pre-glacial cols, left dry by earlier river capture, were frequently used by overflow waters, since they

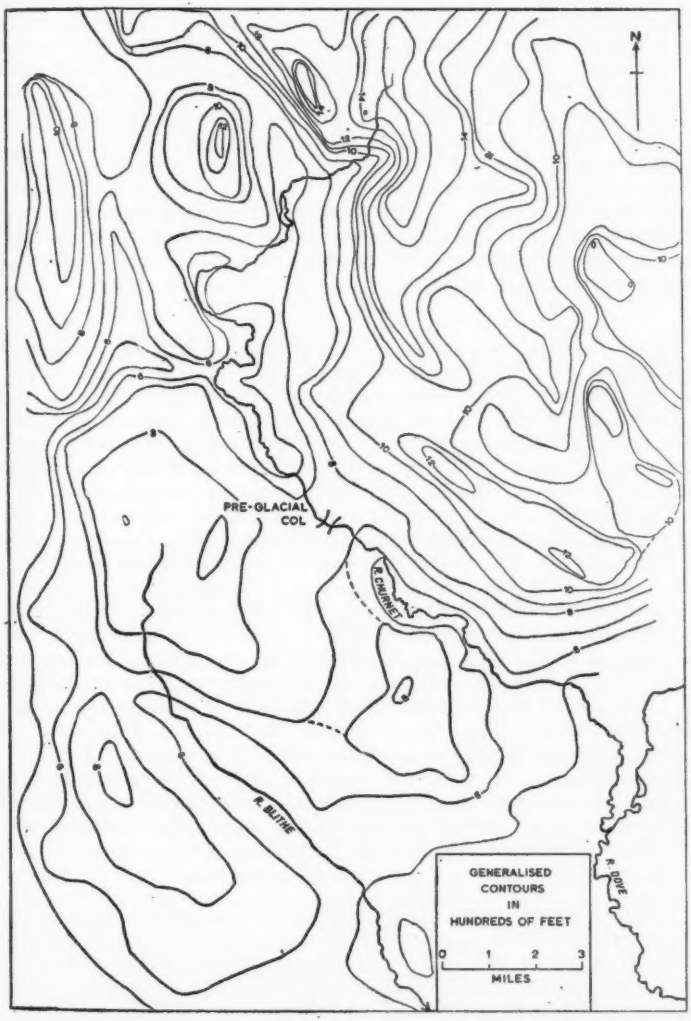

Figure 2—Generalised contour map of the Churnet valley and adjacent areas.

provided the lowest points across watersheds. Yates (1956) has discussed some of the problems of the drainage development. He has pointed out that there is a north-north-west to south-south-east alignment of the Trent headstream, the Horton Brook and the Rudyard valley south of the Cloud, which is repeated further south in the Meece Brook, the Trent south of Stoke-on-Trent and the Blithe. He suggested that this direction was superimposed from a covering stratum resting on an ancient surface sloping in this direction; this surface he calls the Keele surface. The Churnet between Alton and Leek also flows in this same direction. From the evidence shown on the generalised contour map (Fig. 2) it is apparent that these original north-north-west to south-south-east flowing streams were disrupted by capture before the end of the Tertiary. In the area south-west of the Churnet valley between Leek and Rocester, the generalised contour map indicates a surface sloping south-east at 700 to 800 feet, into which the Churnet and Blithe are now incised. A steep bluff to the north, well shown by the projected profiles (Fig. 2), separates this surface from the 1,000 feet surface, here developed on the Carboniferous strata. The lower surface can probably be equated with Clayton's Middle Surface (Clayton, 1953). When the base-level was at about the 700 to 800 feet stage these streams were probably flowing in a predominantly north-north-west to south-south-east direction, but rejuvenation, allowing deepening, has brought about the disruption of this system.

The Trent cutting back from Trentham (863417) north-north-eastwards to the Coal Measures captured some of the south-south-east flowing streams, and developed its north-north-east to south-south-west section which it now follows between Trentham and Heakley Hall (902518), but which in pre-glacial times extended further north-east to the vicinity of Leek. The generalised contour map shows the col at the head of the captured Blithe, and the position of the pre-glacial col in the Churnet valley is also indicated. The most difficult part of the Trent's work in capturing the south-south-east flowing drainage must have been the breaching of the Millstone Grit barrier at Stockton Brook (917520); here, however, the outcrop of the grit is at its narrowest, although the resistance of the rock is shown by the close proximity of the generalised contours and the narrowness of the present col at this point. The breaching of the barrier allowed Horton Brook, excavated along shale bands, to be diverted to the Trent. Further east the Trent cut back into the Trias infilled valley in the neighbourhood of Leek. This allowed fairly rapid down cutting to proceed. The Rudyard stream was also captured,, although at this stage the stream did not extend far to the north-north-west. The watershed lay at the site of the present Rudyard reservoir, where it still is. The relatively high ground here is partly due to the outcrop of a number of bands of grit. The Upper Churnet to the north-east was also diverted into the Trent drainage.

Because of the softer Trias infilling in the valley floor it was possible for the Trent to reverse the drainage in the Churnet valley for a distance of about four miles from Horse Bridge (962536) to a point half a mile south-east of Consall station (000490), the site of the pre-glacial col. The height of this col was about 700 feet and its position is shown on Figure 2.

A reconstruction of the drainage of pre-glacial times, therefore, shows that the Upper Churnet and all the streams to the south-west drained via the Trent to Stone, while cols were left to indicate the points at which the former drainage pattern had been disrupted. The reconstruction of the longitudinal profile of the Churnet valley before its second late-glacial diversion is shown on Figure 3. This has been prepared by using cross sections and spur profiles of the valley at various

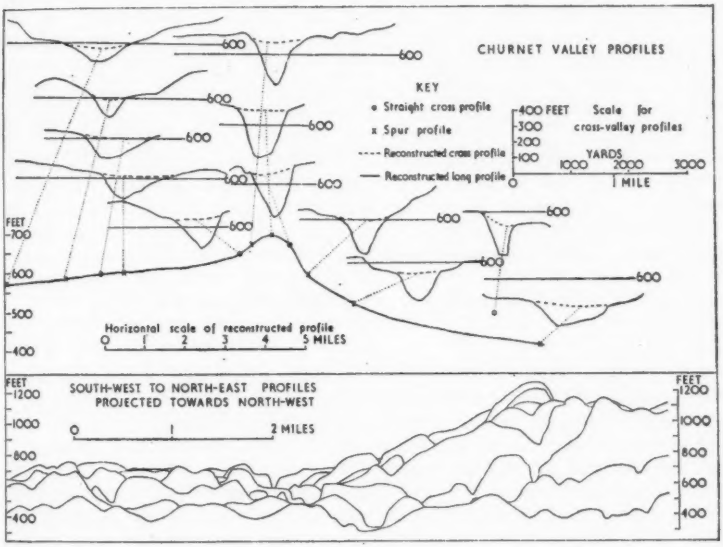

Figure 3—Reconstructed longitudinal profile of the pre-glacial Churnet valley, and projected profiles across the overdeepened portion of the Churnet valley.

The longitudinal profile has been reconstructed from cross-valley profiles and spur profiles, which are also shown. The anomalous cross-profile towards the right of the diagram is related to the outcrop of resistant Bunter Pebble Beds at this point.

The south-west to north-east profiles (below) have been projected towards the north-west. They run approximately at right angles to the overdeepened portion of the Churnet valley.

points at which the former valley floor can be established from definite breaks of slope. The steeper gradient of the south-east flowing portion can be explained by the more rapid recession of a head of rejuvenation at this point which is much nearer the sea via the River Dove, which joins the Trent just downstream of Burton-on-Trent. Any fall of base level would take much longer to reach the upper head waters of the Trent, to which the north-west sloping part of the valley north-west of the col was flowing at this time. The distance was 25 miles to the Dove-Trent confluence for the south-east flowing stream, but more than 50 miles for the north-west flowing stream. At points 6 miles from the former col the levels of the former valley floor were respectively 580 feet to the north-west and 430 feet to the south-east. The difference of 150 feet would represent the fall of the river over a distance of 25 miles,

the difference between the respective lengths of the streams. This approximates closely to the present fall of the Trent of about 120 feet over the same distance.

Glaciation

Ice advanced and retreated several times over this area, but only the effects of the final ice advance are clearly discernable on the landscape. It is quite possible, however, that earlier ice advances and retreats initiated the series of drainage changes which were then re-used and freshened by ice and melt-water in the later phase. The glaciation that will be considered, therefore, is the latest to affect this area, known as the Irish Sea Ice, from its erratic content. The limits of the ice advance have been traced in the north of the area by Jowett and Charlesworth (1929) and in the south by Wills (1937) and Clayton (1953), and are shown on Figure 1. At its maximum the ice front lay across the Blithe valley just down-stream from Cresswell (990383) and ran north-north-east to about the position of the former col in the Churnet valley at the position 007482 and thence northwards, where ice impinged on the western side of Morridge at an altitude of about 1,100 feet.

Owing to the position of the pre-glacial cols a lake was not dammed in the Blithe valley, which drained south-south-east for some miles upstream of the ice front. However, in the Churnet valley a lake was formed as soon as the ice started to retreat, as a result of the reversal of drainage in this part of the valley. The obvious overflow for this lake was across the col near Froghall. The rapid flow of water initiated the deepening of the channel, while further retreat allowed the outlet of the lake to be progressively moved in a north-north-west direction. This back cutting has, therefore, reversed the drainage of this stretch of the valley once more, so that now it flows again in its original direction before capture. A number of lateral drainage channels, discussed by Jowett and Charlesworth (1929), mark the various stages of retreat of the ice sheet westwards. Melt-water used the valley of Combe's Brook, this and the Devil's Staircase (003492) to the south-east and the valley entering the river at Churnet Grange (983523) to the north-west being deepened by overflow water, partially flowing marginal to the ice and in part as overflows from lakes further north. Much of the water was ponded in the Churnet head-streams, but an overflow directed south from a lake in the upper Dane valley passing to the east of the Roaches and Hen Cloud added extraneous water to the Churnet system. This helped to deepen the feeding channels as well as the main Churnet overflow. At a rather later stage water entered the Churnet by Leekbrook (990538). This considerable volume of water was enough to cut down the channel to such a level that the former valley draining south-west to Stoke-on-Trent was permanently abandoned.

A later phase was reached when the ice had retreated over the col at the head of the valley in which the Rudyard gorge now lies. This allowed the Dane drainage and water from a lake impounded to the north of the watershed and entering the Rudyard Lake via Shell Brook

(945640) to flow down the Churnet. This further deepened the valley and resulted in the reversal of drainage of the lower part of Horton Brook, which now enters the Churnet at Horse Bridge (967535). The main valley has now been reversed for a distance of three miles to a point near Stanley (925525). This stream is clearly a misfit as it is only about 3 miles long and occupies a wide mature valley. Below this the main valley is now empty as far as the point where the present headstream of the Trent enters at Heakley Hall (902518). The stream continues as a misfit down the former course of the Churnet.

In form the Churnet valley provides a very good example of the typical overflow channel, cut quickly by large volumes of melt-water. In places it is over 300 feet deep, notably where it cuts across the former col near Froghall. At Alton, although it is only 200 feet deep it is an impressive feature, owing to the resistant nature of the Bunter Pebble Beds, which here form its walls.

Post-Glacial Modifications

The valley has a typical flat floor because aggradation took place when the volume of water flowing down it decreased as the glacial lakes drained and the ice retreated from the area. The same form of channel is maintained from upstream of Leek (962571), where the Churnet turns abruptly south, to downstream of Alton at Crumpwood Weir (425093). The present misfit stream meanders over the wide, flat floor, giving clear evidence of the former larger discharge which shaped the valley. It has been shown that meander wave length bears a definite relationship to discharge (Dury, 1958), and the very large meanders near Leek suggest a very high discharge during the cutting of the channel, as mentioned by Jowett and Charlesworth (1929), while the much smaller modern ones reflect the present small discharge of the Churnet.

Since the retreat of the ice the walls of the trench have been modified by mass movement and by the incision of steep tributaries, as for example between Alton and Oakamoor, where the stream is flowing mainly over Bunter Sandstone.

Conclusion

The course of the Churnet has been shown to have undergone interesting changes as a result of capture and later fluvio-glacial diversion. As a result the Trent having, by the slow process of headward erosion, laboriously captured the pre-glacial Churnet valley, lost it again by the much quicker and more effective agencies of powerful glacial melt-water streams. These changes have resulted in the formation of an impressive gorge, which is a very fine example of a long glacial overflow channel, and have left empty the col by which the Churnet formerly flowed to the Trent near Stoke-on-Trent. This col has proved a convenient route for canal, road and railway, while the flatness of the floor of the Churnet valley has allowed this route to be used throughout its length by a railway.

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BEESTON: AN INDUSTRIAL SATELLITE OF NOTTINGHAM

D. M. SMITH

An important feature of the economic development of Great Britain since the end of the eighteenth century has been the growth of villages into industrial towns. This has been particularly common in those parts of the East Midlands where a tradition of domestic hosiery manufacture was followed by factory production during the second half of the nineteenth century or by the development of other industries, such as the manufacture of lace and footwear. Beeston, near Nottingham, provides an interesting example of this type of industrial growth. The purpose of this article is to describe the present industrial geography of Beeston in relation to that of the Nottingham area as a whole, and to explain its development in the general context of the industrial history of this part of the East Midlands.

Beeston lies four miles west-south-west of the centre of Nottingham. It forms the chief settlement in the Urban District of Beeston and Stapleford, which had a population of 49,846 in 1951(1), when 33,549 persons lived in Beeston and Chilwell, in effect one urban unit; 12,663 in Stapleford overlooking the Erewash valley; and the remainder in the parishes of Bramcote (1,824) and Toton (1,810), including the village of Attenborough. This study is mainly confined to the town of Beeston, consisting of the built-up area of Beeston and Chilwell parishes, but some consideration is given to the Urban District as a whole.

THE PRESENT INDUSTRIAL GEOGRAPHY OF BEESTON

Beeston and Stapleford U.D. is one of five Urban Districts adjacent to the County Borough of Nottingham (Figure 1). Arnold, Carlton and West Bridgford are now continuations of the built-up area of the city, but Hucknall is in a more detached position, and Beeston, separated from the city by the small green belt of Wollaton Park, University Park, and the University and Nottingham Corporation playing fields, is also a more physically separate urban unit. Beeston and Stapleford U.D. differs from the other four Urban Districts as regards its functions within the Greater Nottingham area. *Table 1 shows that while the others all have a net daily loss of working population Beeston and Stapleford U.D. has a net inward movement of over 4,600 workers. Beeston and Stapleford is also the only Urban District which attracts more workers from Nottingham than leave it to work in the city. In addition more Nottingham people work in Beeston and Stapleford than in the other four Urban Districts taken together.

The functional difference between Beeston and Stapleford and the other Urban Districts is further emphasised by a comparison of their employment structures (Table 2 A). Agriculture is of little importance in any of the areas, but mining and quarrying, though insignificant in Beeston and Stapleford, employs many in Carlton and Hucknall. In Beeston and Stapleford manufacturing industries are important, and employ more persons (14,547) than in the other Urban Districts taken together. Service industries are almost as important in Beeston and

*The Tables appear on pages 51 to 55

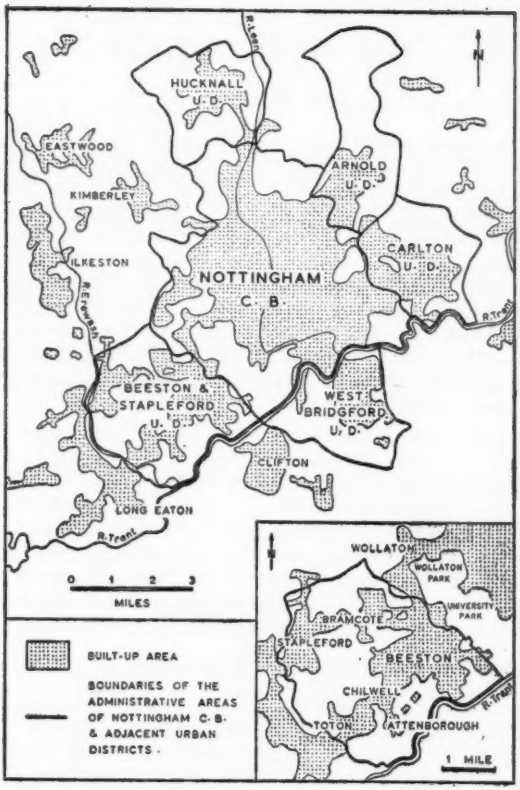


Figure 1

The location of Beeston and Stapleford Urban District in relation to Nottingham.

NOTE : the boundaries of local government areas are those existing in 1951. Since this date Nottingham C.B. has been extended to take in the new Clifton estate and the boundary of West Bridgford has also been altered.

Stapleford as manufacturing, and the 49 per cent. employed in this group is the same proportion as in Nottingham C.B. However, the figure for Beeston and Stapleford includes about 5,000 persons employed in the army ordnance depot at Chilwell, the presence of which tends to over-emphasise the service function of Beeston and Stapleford, as the depot would be more appropriately described as an engineering works. If these workers are excluded, the proportion in service industries falls to 36 per cent., and that in manufacturing rises to 63 per cent., a figure well above that for Nottingham and its adjacent Urban Districts treated as a whole. By comparison with the other suburban towns then, Beeston stands out as by far the most important centre of manufacturing industry.

The physical separation of Beeston from Nottingham and its importance as a centre of industrial employment would appear to justify its description as an industrial satellite rather than suburb, a term which

is more appropriately applied to those mainly residential areas which form a continuation of the city of Nottingham.

In the Nottingham district the two main manufacturing groups—the metal and engineering industries and the textile industries—are of roughly equal importance (Table 2 B), but in Beeston and Stapleford U.D. over half the manufacturing workers are employed in the metal and engineering group, a higher proportion than in any of the other Urban Districts. The proportion in textile manufacture, only 15 per cent., is much smaller than in the other Urban Districts, and the manufacture of clothing is also relatively less important. The second manufacturing group in Beeston and Stapleford, chemicals and ceramics, with 20 per cent., employs a relatively small number of persons in the other Urban Districts.

Employment in manufacturing industry in Beeston and Stapleford U.D. is shown in more detail in Table 3, which emphasises the importance of two industries dominated by two large firms : electrical engineering (Ericsson Telephones, Ltd.) and chemicals and allied trades (Boots Pure Drug Company, Ltd.). Compared with these two industries, which together employ over half the manufacturing workers of the district, the textile industries, represented mainly by the manufacture of hosiery and lace(2) are much less important. Most of the remaining employment is in the metal and mechanical engineering industries, including the manufacture of boilers and machine tools, and in the manufacture of clothing, mainly foundation garments and surgical appliances. The proportion of females employed in manufacturing in Beeston and Stapleford, 36.6 per cent. is above the national average of 31.3 per cent., but well below that of the Nottingham district as a whole, where the proportion is 43.4 per cent.

The present location of manufacturing industry in the town of Beeston is shown in Figure 2. The large plants of Boots, Ericsson, and the Beeston Boiler Company, situated on the flat flood plain of the River Trent beside the Nottingham-Derby railway line, are distinct from the group of much smaller plants concentrated in the older industrial area of Beeston on a gravel terrace in the neighbourhood of the junction of Station Road and Wollaton Road with the High Road. These smaller works are mainly concerned with the manufacture of hosiery, lace, and other textiles, but include a number of engineering firms. There are similar groups of small plants on the south side of Chilwell Road, on By-Pass Road, and on Queens Road. A few factories employing two to three hundred persons fall into an intermediate category between the large plants of the flood plain and the smaller manufacturing units.

The evolution of the present industrial geography of Beeston will now be examined in three stages.

Early Development : The Industrial Village

Beeston originated during the Anglo-Saxon colonisation of the Midlands as a small settlement on a river gravel terrace lying on the northern side of the flood plain of the Trent. The settement persisted as an agricultural village operating the three-field system for many hundreds of years(3). Early in the eighteenth century, the domestic hosiery industry, or framwork knitting, appeared in Beeston(4), at the time when the trade was beginning to provide an important source of

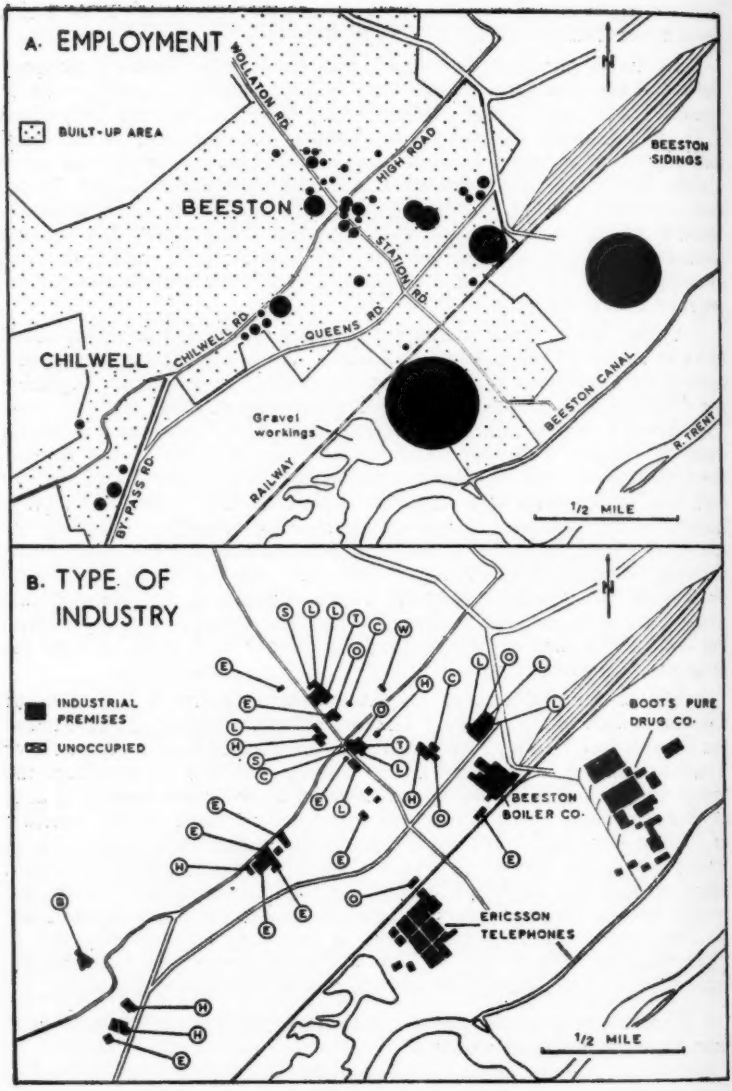


Figure 2

Manufacturing industry in Beeston, 1958.

A. EMPLOYMENT. The circles are drawn in proportion to the number of persons employed in each firm with ten or more workers. In order that employment in individual firms should not be divulged it has been considered advisable to omit the key.

B. TYPE OF INDUSTRY.

Key: L Lace; H Hosiery; S Silk; T Other textiles; C Clothing; E Engineering; B Bricks; O Other manufacturing industries

Source: H.M. Factory Inspectorate, Nottingham District Registers.

alternative employment in many of the agricultural villages round Nottingham. The expansion of framework knitting in Beeston was helped by the turnpiking of the road from Lenton to Sawley Ferry (1758-59), which strengthened the connection between the village and Nottingham(5). Later, in 1806, an Enclosure Act freed land for building, and led to a population increase of 42 per cent. between 1801 and 1811 (Table 4). Examples of framework knitters' houses with the elongated workshop windows still remain in the old part of Beeston and elsewhere, particularly along the Derby Road between Bramcote and Stapleford.

During the early nineteenth century a second textile industry, the manufacture of lace, was established in Beeston, and by 1826, sixty-nine bobbin net machines were at work in the village(6). A period of great prosperity for the Nottingham lace industry began in the eighteen-twenties, but restrictions on building on the common lands surrounding the overcrowded town of Nottingham led to an outward movement of the industry into the surrounding district. Between 1831 and 1842 the number of lace machines in Nottingham fell by six hundred, and the number in Radford, Lenton, Sneinton, Beeston and Carrington increased accordingly(7). In 1831, a hundred and thirty bobbin net machines were operating in Beeston and Chilwell, with a further twenty-five in Stapleford; and by 1836 the number in the Beeston district had risen to two hundred and two, over half producing fancy lace(8). Of the outer ring of villages surrounding Nottingham, only Beeston participated to any important extent in this spatial expansion of the lace industry, for most of this early industrial overspill from the town went to the inner ring of villages—Sneinton, Carrington, and the lower Leen Valley settlements(9).

The factory system was also represented in Beeston during the early part of the nineteenth century, in addition to the domestic hosiery and lace industries. In 1826 William Lowe, a Nottingham silk hosier, built in the village a large silk throwing and doubling mill which was employing about two hundred persons by 1831, when it was burned down in the Reform Bill riots(10). The mill was rebuilt, and became the property of F. B. Gill, who was employing five hundred and thirty persons by 1851(11), when the Beeston silk mill must have been the largest factory between Nottingham and Derby.

The expansion of the lace industry and the development of the silk mill were mainly responsible for the population increase of 65 per cent. in Beeston between 1821 and 1831 (Table 4). Although Beeston was still a small settlement in 1836, it was considerably larger than nearby Chilwell and Attenborough, and extensions towards and beyond the turnpike road were already taking place. The silk mill, the only large industrial building, stood at the junction of the turnpike and what is now Station Road (Figure 3 A).

The growth of other textile industries permitted little further expansion of framework knitting in Beeston during the first half of the nineteenth century. Indeed, the domestic hosiery industry of the East Midlands was in a state of stagnation, with much excess capacity, and the framework knitters of the Beeston district suffered low wages, frequent payments in goods, and other abuses which were common to

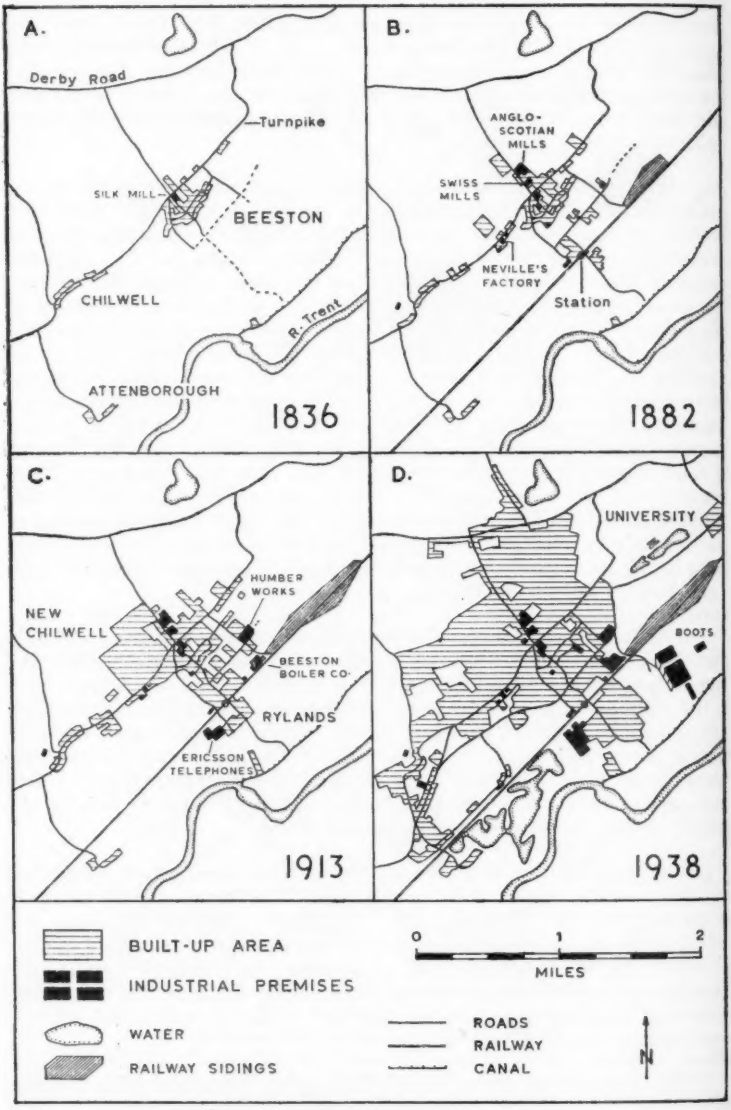


Figure 3
The Development of Beeston, 1836-1938

the industry as a whole(12). Yet framework knitting remained an important occupation in Beeston, and in 1844 there were 275 frames in the village, almost exclusively producing fashioned cotton goods, like others nearby at Chilwell (77 frames), Bramcote (33), Stapleford (33), and Attenborough (27) (13). But framework knitting was less important in Beeston, with one frame to ten people, than in some other villages, such as Hucknall, Arnold, Calverton and Carlton, where no alternative industrial employment existed, and where there was one frame to every four persons.

The occupational structure of Beeston in 1851 is summarised in Table 5, which shows the dominance of the textile manufacturing trades, employing 1,035 persons, or two-thirds of the total occupied population The most important industry was the manufacture of lace, employing 396 compared with 238 in the domestic hosiery industry. Most of the men worked stocking or lace machines, while the women and children either assisted as stocking seamers or lace menders, or worked in the silk mill, which employed 377 Beeston workers, as well as others from outside the parish. Agriculture, employing only 93 persons, was now relatively unimportant. Thus, by the middle of the nineteenth century, Beeston, like many other settlements in the East Midlands, had become an important industrial village, and the days of dependance on agriculture had passed.

Industrial Expansion : The Lace Manufacturing Town

The middle decades of the nineteenth century were a period of consolidation rather than of rapid expansion in the industrial development of Beeston, despite the construction in 1839 of the Nottingham to Derby railway, which passed close to the village. The enclosure of the common land after 1845 made possible the building of factories on the fringes of Nottingham and the lace industry therefore now tended to expand further in the town itself rather than in the villages. The depressed framework knitting industry declined, unable to compete with the newly built hosiery factories of Nottingham. In 1855 the number of stocking frames in Beeston had already fallen to about 200, and by 1864 only about 50 remained(14). The rapid population increase between 1821 and 1841 during the lace boom was thus followed by more stable conditions, and between 1841 and 1871 the population of Beeston increased by only 327 persons (Table 4), suggesting that there was now some degree of outward migration, probably into Nottingham.

During this period important changes were taking place in the organisation of the lace industry, for the application of steam power to lace machinery soon led to the expansion of factory production. By 1840 Robert and William Felkin had small factories for making hosiery and plain net in Beeston(15) and in 1851 Thomas Elliot, lace manufacturer, was employing sixty persons(16). By 1861 William Felkin had 53 lace machines at work in his Beeston factory, and William Felkin junior had a factory containing 39 machines nearby(17). These were fairly large plants at a time when the largest ten or so lace factories in the Nottingham district held from 70 to 170 machines(18), but small compared with factories which were to be built before the end of the century.

The large-scale development of the factory lace industry in Beeston really began in the late eighteen-seventies and the eighteen-eighties, when a second period of rapid industrial expansion began. At this time the lace industry of the Nottingham district was developing rapidly, but in the town of Nottingham the lace trade unions were forcing up wages and attempting to impose restrictions on output. As competition from abroad increased, many mnaufacturers found it necessary to move to places where the unions were less powerful(19). The result was a second period of dispersal to the villages to the west of Nottingham, where Beeston and other places, such as Long Eaton, Draycott, Sandiacre and Ilkeston, had the advantages not only of cheaper (non-union) labour, but also of cheap land for factories and good rail communications with Nottingham(20). The lace industry grew rapidly in these villages, and Beeston soon became an important industrial town.

During this period of expansion, three large lace factories were built, and subsequently extended, in Beeston: the Swiss Mills and Anglo-Scotian Mills along Wollaton Road, and Neville's Factory along the Chilwell Road (Figure 3 B). The Swiss Mills were built by John Pollard as a tenement factory (in 1891 they contained thirteen separate lace manufacturing firms(21)), and William Neville's factory operated on the same system. The Anglo-Scotian Mills, however, together with a small branch near Neville's Factory, where until the beginning of the twentieth century operated by one manufacturer, who produced lace curtains and also Shetland hosiery and shawls(22). The Anglo-Scotian Mills, with an elaborate brick facade and crennellations, is architecturally one of the most interesting industrial buildings in the East Midlands, and contrasts with the more austere appearance of the nearby Swiss Mills.

The expansion of the lace industry brought a new period of prosperity to Beeston, and the population more than doubled between 1871 and 1891 (Table 4). The number of lace manufacturers increased from 14 in 1881 to 29 in 1891 (Table 6), and by 1912 there were 33 manufacturers in the town, employing about 1,100 workers. The initial increase was mainly in the fancy lace trade, but later there were important advances in the lace curtain and net branches. The vigorous expansion of the lace trade allowed little development of the factory hosiery industry, and between 1876 and 1899 the number of hosiery manufacturers was reduced from 5 to 2 (Table 6). These made Shetland hosiery and shawls, a specialisation which Beeston shared with Hucknall.

Throughout the second half of the nineteenth century the silk mill continued to provide an important source of employment in Beeston, but finally, like those of Derby, it succumbed to competition from abroad. In 1881 it still employed about 500 persons, but by 1891 the number had fallen to 300-400(23), and in 1902 the mill stopped work as a silk factory, and was partly demolished(24).

Industrial Diversification and Residential Development

In 1880 the Nottingham cycle manufacturing firm of Humber, Marriot and Cooper, requiring room for expansion, built a large new factory in Beeston(25), the first on the flat land of the flood plain. This

event marked the end of the period of textile domination and thus the beginning of the diversification of the industrial structure of the town. A few years later the firm became Humber and Company, and for a time the "Beeston Humber" rivalled the "Raleigh" in local fame(26). Other cycle works were set up in Beeston by Humber workers, and in 1899 there were four in the town (Table 6). In 1898 Humber began to make motor cars in Beeston(27), but in 1908, when 1,400-1,500 persons were being employed, production was concentrated in Coventry. Three thousand people left Beeston with the firm, and six hundred houses were vacated(28). The vacuum thus created was soon filled by the lace industry, for the Humber works were bought by Sir A. W. Black to manufacture net for his finishing-house in Nottingham(29).

Beeston's participation in the Nottingham cycle boom and the continued expansion of the lace industry caused a rapid extension of its built-up area (Figure 3 B and C). Population increased from 6,948 in 1891 to 11,336 in 1911, and the growth of the town was given further impetus by its development as a residential area for Nottingham. As early as 1881 its good rail communications attracted Nottingham manufacturers and merchants to live in Beeston(30), and areas of good class housing were built at Beeston Rylands and north of the Chilwell Road in an area which was known for a time as New Chilwell(31). The increasing residential function of Beeston is emphasised by a rise in the number of trains to and from Nottingham each day from 54 in 1876 to 100 in 1899(32).

After the Humber Company left Beeston the diversification of industry in the town was continued by the growth of the British L. M. Ericsson Manufacturing Company, which began making telephones in a former cycle works near Beeston station in 1903, with a labour force of 130(33). The flood plain site provided all the necessary room for expansion, and by 1916 employment had risen to over 1,000(34). Further growth occurred after the first World War, with increasing demand for telephonic equipment, and by 1939 over 4,500 were employed(35). The beginning of the twentieth century also saw the expansion of the Beeston Boiler Company on a site in the flood plain to which the firm had moved from a foundry in the older part of the town in 1897(36).

After the first World War the decline of the lace industry of the Nottingham district, by reducing the number of manufacturers in Beeston from 32 in 1922 to 20 in 1936 (Table 6), brought further changes in the industrial structure of the town. Between 1901 and 1931 the proportion of the occupied population working in the textile industries fell from 36 per cent. to 14, while employment in the engineering and metal industries rose from 15 to 22. The diversification of industry in Beeston is further emphasised by an increase from 253 in 1901 to 892 in 1931 in employment in a variety of other manufacturing industries, including clothing (Table 7) (37). A particularly interesting example of the replacement of the lace industry by engineering is provided by the Myford Engineering Co., Ltd., which began on a small scale in Neville's Factory in 1934 and which eventually expanded to take over the whole building(38). The process of industrial diversification in Beeston culminated in the setting up of large factories by Boots Pure Drug Company in 1932 and 1938 on an extensive site in the flood plain to the south-east of the town after the firm had outgrown its

accommodation in the centre of Nottingham. The Beeston factories employed about 4,000 persons and their construction also marked an important stage in the development of modern industrial architecture(39).

The occupied population of Beeston almost doubled during the first thirty years of the twentieth century, but, although employment in manufacturing rose from 1,960 to 3,445, the proportion of the total occupied in this group fell from 59 per cent. to 49, while employment in service industries rose from 37 per cent. to 49 (Table 7), an increase partly attributable to the expansion of the army ordnance depot at Chilwell, established as a shell filling works during the first World War. The development of the ordnance depot, which became an important source of employment, gave further impetus to the growth of Beeston.

Following the first World War the development of motor-bus services and the increasing use of the motor-car caused the further growth of Beeston as a residential district for people working in Nottingham, and large-scale extensions of the built-up area thus occurred (Figure 3 C D), From 1911 to 1931 the population of Beeston rose by almost 5,000 and by 1951 a further increase of almost 8,000, or 53 per cent., had taken place. Between 1931 and 1951 the population of the Beeston and Stapleford Urban District, formed in 1935 by the amalgamation of Beeston Urban District and Stapleford Rural District, rose from 27,812 to 49,846, an increase of 82 per cent., and by 1959 a further increase to 55,320 had occurred. Since the second World War more residential extensions to the built-up area of Beeston have taken place, particularly to the north of the Derby Road. Here, in Wollaton and the Wollaton Vale estate, a continuous connection of built-up area now exists between Beeston and Nottingham (Figure 1).

Since the last war the engineering and metal industries have continued to expand in Beeston, employment increasing from 6,096 in 1948 to 9,233 in 1958 (Table 8), mainly due to the continued growth of Ericsson Telephones with a renewal of pre-war demand and the development of new overseas markets(40). Employment in the textile industries has remained fairly steady, with a fall in the number of lace manufacturers being offset by expansion of the hosiery trade. Employment in other manufacturing industries, including chemicals, has fallen slightly. Between 1948 and 1958 employment in manufacturing increased by almost 3,000 but a decrease of about 2,000 occurred in service industries, mainly due to the gradual reduction of employment at the Chilwell Ordnance Depot (included in National and Local Government in Table 8).

Conclusion

The earlier industrial growth of Beeston was in many respects typical of that experienced by those agricultural villages of the East Midlands which developed into framework-knitting centres, and then into factory villages or small towns specialising in the manufacture of hosiery, or, in some cases, lace or footwear. However, unlike most other places, Beeston experienced a later stage of industrial diversification associated with its proximity to the city of Nottingham, and with its subsequent envelopment in the Greater Nottingham conurbation. Of particular importance in the industrial development of Beeston have

been the good railway communications with Nottingham and the presence of large areas of level and subsidence-free land in the flood plain of the Trent close to the city. These advantages have led to the building of large industrial plants, a type of growth which has not occurred on the same scale in other places in the East Midlands which began their industrial development as framework knitting villages.

Since the beginning of the eighteenth century Beeston has thus experienced distinct phases of industrial growth, and the development of Beeston as a town has been closely related to these stages, each of which is still represented in the urban landscape to-day, a landscape typical of much of the industrial East Midlands. In the old nucleus of Beeston, between the High Road and Queens Road, a few surviving farmhouses and framework knitters' cottages represent the period of the domestic hosiery industry and the transition from an agricultural to an industrial village. The red brick lace mills, typical of Victorian industrial architecture, and the late nineteenth century terrace houses represent the period dominated by factory textile industries and the rise of Beeston as a lace manufacturing town. The large industrial plants of the flood plain and the extensive areas of twentieth century residential development represent the period of industrial diversification and the participation of Beeston in the general expansion of Greater Nottingham.

TABLE 1

DAILY MOVEMENT TO WORK, 1951

	Urban Districts				
	Beeston & Stapleford	*Arnold*	*Carlton*	*Hucknall*	*West Bridgford*
Total outward movement	9,234	6,921	9,490	3,791	9,024
To Nottingham C.B.	5,047	5,181	8,189	1,843	7,510
To other places	4,187	1,740	1,301	1,948	1,514
Total inward movement ..	14,061	1,349	4,228	2,147	1,381
From Nottingham ..	5,965	722	2,748	976	909
From other places ..	8,096	577	1,480	1,171	472
Net daily gain (+) or loss (—)	+4,827	—5,572	—5,262	—1,644	—7,643

Source: *Census of England and Wales, 1951, Report on Usual Residence and Workplace* (London, H.M.S.O., 1956).

TABLE 2

THE EMPLOYMENT STRUCTURE OF NOTTINGHAM AND ADJACENT URBAN DISTRICTS, 1951

	Beeston & Stapleford U.D.		*Arnold U.D.*		*Carlton U.D.*		*Hucknall U.D.*		*West Bridgford U.D.*		*Nottingham C.B.*		*Total*	
	No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
A. INDUSTRIAL STRUCTURE														
Agriculture, etc.	188	1	173	4	101	1	100	1	85	2	237	—	974	—
Mining and Quarrying	81	—	222	5	2,315	21	2,674	29	9	—	2,480	2	7,781	4
Manufacturing	14,547	50	1,839	42	4,101	38	3,173	35	717	20	83,657	49	108,034	48
Services	14,226	49	2,193	49	4,346	40	3,133	35	2,792	78	84,369	49	111,059	48
Total Employed*	29,051		4,429		10,866		9,081		3,606		170,898		227,931	
B. STRUCTURE OF MANUFACTURING INDUSTRY														
Ceramics, Chemicals, etc.	3,810	26	42	2	309	8	5	—	165	23	5,756	7	10,087	9
Metals and Engineering	7,376	51	197	11	1,236	30	1,254	40	233	33	21,989	26	32,285	30
Textiles	2,090	15	853	46	1,158	28	1,341	42	26	3	23,597	28	29,065	27
Clothing	518	3	88	4	134	3	249	8	62	9	11,283	14	12,334	11
Others	753	5	659	36	1,264	31	324	10	231	32	21,032	25	24,263	23
Total Employed	14,547		1,839		4,101		3,173		717		83,657		108,034	

*Includes workers under the heading of "not stated and ill-defined industry".

—Indicates less than 1%

Source: *Census of England and Wales*, 1951, *Industry Tables*, (London, H.M.S.O., 1957).

TABLE 3

BEESTON AND STAPLEFORD U.D.
EMPLOYMENT IN MANUFACTURING INDUSTRY, 1951

	Males	*Females*	*Total*	*Percentage of Total*
Ceramics, glass, cement, etc.	44	6	50	0.4
Chemicals and allied trades	1,870	1,890	3,760	25.9
Metal manufacture	776	52	828	5.7
Mechanical engineering	599	80	679	4.7
Electrical engineering	3,198	896	4,094	28.2
Vehicles	824	18	842	5.8
Other metal goods	412	521	933	6.4
Precision instruments, jewellery, etc. ..	28	27	55	0.4
Hosiery and other knitted goods	373	747	1,120	8.4
Silk, rayon, nylon, etc.	39	36	75	0.5
Textile finishing	166	63	229	1.6
Other textiles	324	342	666	4.6
Clothing	120	398	518	3.6
Food, drink and tobacco	106	15	121	0.8
Wood and cork	197	46	243	1.7
Paper and printing	85	52	137	0.9
Other manufacturing industries	62	135	197	1.4
TOTAL ..	9,223	5,324	14,547	

Source: *Census of England and Wales, 1951, Industry Tables* (London H.M.S.O., 1957)

TABLE 4

POPULATION OF THE PARISHES OF BEESTON AND STAPLEFORD U.D., 1801–1951

	Parishes						*Beeston and Stapleford U.D.*	
	Beeston		*Bramcote*	*Chilwell*	*Stapleford*	*Toton*		
	No.	*% change*	*No.*	*No.*	*No.*	*No.*	*No.*	*% change*
1801	948		354	638	748	175	2,863	
1811	1,342	+42	378	691	954	179	3,544	+24
1821	1,534	+15	441	823	1,104	208	4,110	+16
1831	2,530	+65	562	892	1,533	202	5,719	+39
1841	2,807	+14	732	896	1,837	140	6,212	+ 9
1851	3,016	+ 7	722	897	1,968	133	6,736	+ 8
1861	3,195	+ 6	691	910	1,729	200	6,725	—(2)
1871	3,134	— 2	616	887	1,967	201	6,805	+ 1
1881	4,479	+43	751	1,046	3,196	193	9,665	+43
1891	6,948	+56	762	1,013	4,255	245	13,223	+37
1901	8,960	+29	745	1,176	5,766	186	16,799	+22
1911	11,336	+27	683	1,359	7,789	176	22,343	+33
1921	12,494	+10	719	2,125	8,513	162	24,013	+ 8
1931								
(a)(1)	16,017	+28	987	2,584	8,838	644	29,070	+21
(b)	14,759		987	2,584	8,838	644	27,812	
1951	22,551	+53	1,824	10,998	12,663	1,810	49,846	+82

Note: (1) In 1933 a boundary change resulted in the transfer of part of Beeston parish to Nottingham C.B. The 1931 population is shown for the area of Beeston C. P. before (a) and after (b) this change.
(2) — indicates a negative change of less than 1%.

Source: *Census Reports, 1801–1951.*

TABLE 5

OCCUPATIONS OF THE POPULATION OF BEESTON PARISH, 1851

AGRICULTURE	**93**
MINING	**1**
MANUFACTURING	**1,259**
Lace making	282
Lace mending, etc.	114
Framework knitting	186
Hosiery seaming, stitching, etc.	52
Silk	377
Cotton	24
Clothing	119
Engineering and metal goods	47
Other manufacturing industries	58
SERVICES	**275**
Retail distribution	45
Personal service	167
Professional services	31
Other services	32
Labourers (undefined)	42
TOTAL OCCUPIED	**1,670**

Source: *1851 Census Enumeration Schedules, Public Records Office*, H.O. 107/2127.

TABLE 6

NUMBER OF MANUFACTURERS IN SELECTED INDUSTRIES IN BEESTON, 1864–1958

	Lace Industry			*Hosiery Industry*			*Engineering Industries*		
	Lace	*Curtains and Net*	*Total*	*Hosiery*	*Shawls etc.*	*Total*	*Metals and Engineering*	*Cycles*	*Total*
1864	13	—	13	—	—	—	—	—	—
1876	14	—	14	4	1	5	1	—	1
1881	13	1	14	2	2	4	1	1	2
1891	27	2	29	1	2	3	2	1	3
1899	18	2	20	—	2	2	1	4	5
1912	24	9	33	3	1	4	7	2	9
1922	17	15	32	2	2	4	6	1	7
1936	14	6	20	4	2	6	10	1	11
1958	5	4	9	6	1	7	13	—	13

Sources: *Kelly's Directories of Nottinghamshire, 1864–1936.*

H.M. Factory Inspectorate, Nottingham District Registers (1958).

TABLE 7

OCCUPATIONS OF THE POPULATION OF BEESTON, 1901–1931

	1901		1911		1921		1931	
	No.	%	*No.*	%	*No.*	%	*No.*	%
AGRICULTURE	**101**	**3**	**145**	**3**	**147**	**3**	**145**	**2**
MINING AND QUARRYING	**45**	**1**	**68**	**1**	**72**	**1**	**31**	—
MANUFACTURING	**1,960**	**59**	**2,779**	**56**	**2,771**	**52**	**3,445**	**49**
Engineering and metal goods	514	15	985	20	1,243	23	1,559	22
Textiles	1,193	36	1,287	26	909	17	994	14
Clothing	190	6	258	5	253	5	348	5
Other manufacturing industries	63	2	249	5	366	7	544	8
SERVICES	**1,162**	**37**	**1,975**	**40**	**2,387**	**45**	**3,514**	**49**
Other occupations	658		225		372		597	
TOTAL OCCUPIED	**3,926**		**5,292**		**5,749**		**7,732**	

Note: The percentage figures refer to percentage of total occupied excluding those in "other occupations".

Sources: *Census of England and Wales, Nottinghamshire, Occupational returns for Beeston U.D., 1901, 1911, 1921, Occupation Tables, 1931.*

TABLE 8

NUMBER OF INSURED EMPLOYEES IN BEESTON LABOUR EXCHANGE AREA, 1948–58

	1948		1953		1958	
	No.	%	*No.*	%	*No.*	%
AGRICULTURE, MINING AND QUARRYING	**214**	**1**	**212**	**1**	**180**	**1**
MANUFACTURING	**12,094**	**55**	**13,584**	**65**	**14,911**	**66**
Engineering and metals	6,096	28	7,803	37	9,233	41
Textiles	1,356	6	1,395	7	1,279	6
Clothing	252	1	399	2	366	2
Other manufacturing industries	4,390	20	3,987	19	4,033	17
SERVICES	**9,401**	**44**	**6,970**	**34**	**7,433**	**33**
National and local government	5,580	25	4,231	20	3,825	17
Other Services	3,821	19	2,741	14	3,608	16
TOTAL	**21,789**		**20,766**		**22,524**	

Note: The Employment Exchange Area includes Beeston, Chilwell, Bramcote and Attenborough, but not Stapleford and Toton.

Source: Ministry of Labour, North Midland Regional Office.

NOTES

(1) The estimated population of the Urban District in 1959 was 55,320. *Annual Estimates of the Population of England and Wales and of Local Authority Areas*, 1959 (London, H.M.S.O., 1959) p. 9.

(2) Employment in the manufacture of lace is included under the heading of "other textiles", for the industry is not distinguished separately in the Industry Tables of the 1951 census for Urban Districts with a population of less than 50,000.

(3) The pre-industrial history of Beeston is not considered in this article. For information on the subject see :

A. COSSONS, "Beeston", in *Beeston and Stapleford Official Guide*, edited by J. Burrows & Co., Cheltenham and London, pp. 22-26.

R. MELLORS, *Beeston : Then and Now* (Nottingham, 1916).

REV. T. J. OLDRINI, *Gleanings, or Something about Beeston in the Olden Times* (Nottingham, 1873).

(4) MELLORS, op. cit., p. 37. Men are frequently described as framework knitters in the parish registers after this time.

(5) This Act (32 Geo. II c.53) allowed inhabitants of Beeston, Chilwell, and Bramcote to pass without paying at Lenton gate in consideration of ten shillings a year from the poor rate of each village. A. COSSONS, *The Turnpike Roads of Nottinghamshire*, Historical Association Leaflet No. 97 (London, 1934) p.24 and pp.36-37.

(6) W. FELKIN, *A History of the Machine-Wrought Hosiery and Lace Manufactures* (Cambridge, 1867) p.333.

(7) *Second Report of the Commissioners for inquiring into the Employment and Condition of Children in Mines and Manufactories*, British Parliamentary Papers, 1843, XIV, Appendix p. f49.

(8) *First Report from the Select Committee appointed to inquire into the Operation of the Existing Laws Affecting the Exportation of Machinery*, B.P.P., 1841, VII, Appendix 4, p. 243, and Appendix 6, p.251.

(9) For further details see J. M. HUNTER, *Greater Nottingham : a Geographical Study of Industrial Development*, unpublished doctoral thesis, University of Reading, 1953, *passim*.

(10) See *The Nottingham Review*, Friday, March 16, 1832, and W. WHITE, *History, Gazetteer, and Directory of Nottinghamshire* (Sheffield, 1832) p.112.

(11) 1851 Census Enumeration Schedules, Public Records Office, H.O. 107/2127, p.19.

(12) *Report of the Commissioner appointed to inquire into the Condition of the Framework Knitters*, B.P.P., 1845, XV, Appendix, Parts I and II. For details of conditions in the Beeston Area, see evidence of S. G. Horsley in Appendix, Part II, pp.115-116.

(13) Ibid., p. 10-11.

(14) *Kelly's Directory of Nottinghamshire*, 1855, p.11 ; 1864, p.435.

(15) MELLORS, op. cit., p. 39.

(16) Public Records Office, H.O. 107/2127, p.26.

(17) *Report on the expediency of subjecting the Lace Manufacture to the Regulation of the Factory Acts*, B.P.P., 1861, XXII, p.59.

(18) Ibid., *passim*.

(19) *Second Report of the Royal Commission appointed to inquire into the Depression of Trade and Industry*, B.P.P., 1886, XXI, pp.241-243.

(20) D. M. SMITH, "The Nottingham Lace Industry", *Northern Universities' Geographical Journal* (1960) p.11.

(21) *Kelly's Directory of Nottinghamshire*, 1891, pp.1012-1014.

(22) MELLORS, loc. cit.

(23) *Kelly's Directory of Nottinghamshire*, 1881, p.15 ; 1961, p.1012.

(24) MELLORS, op. cit., p.18.

(25) Most of this factory still remains at the junction of Humber Road and Queens Road (Fig. 3C) and one wall still bears the trade mark of the Humber Company. For details of the early history of the firm in Beeston see H. O. DUNCAN, *The World on Wheels* (Paris, 1926) pp.350-351 and 357-359 and MELLORS, op. cit., pp.39-40.

(26) F. A. WELLS, "Nottingham Industries, a Hundred Years of Progress" in *A Century of Nottingham History*, 1851-1951 (Nottingham, 1952) p.33.

(27) G. R. DOYLE, *The World's Automobiles*, 1880-1958 (London, 1959) p.91.

(28) MELLORS, op. cit., p.40.

(29) *Beeston and Stapleford Official Guide*, p.87.

(30) *Kelly's Directory of Nottinghamshire*, 1881, p.15.

(31) A. COSSONS, "Chilwell and Toton" in *Beeston and Stapleford Guide Official*, p.31.

(32) *Kelly's Directory of Nottinghamshire*, 1825, p.659 ; 1899, p.22.

(33) *Beeston and Stapleford Official Guide*, p.82. This company was formed jointly by the Swedish firm of L. M. Ericsson and Co., and the National Telephone Co. of Beeston. In 1926 the present title of Ericsson Telephones Ltd. was adopted.

(34) MELLORS, op. cit., p.40.

(35) Ericsson Telephones Ltd., Article in *The Nottingham Observer* August 1956, pp.36-37.

(36) *Beeston and Stapleford Official Guide*, pp.75-77.

(37) The figures in Table 7 refer to the occupational structure of the resident population of Beeston, and not to the employment structure of persons working in the area, as in Tables 2, 3, and 8.

(38) *Beeston and Stapleford Official Guide*, p.79.

(39) N. PEVSNER, *The Buildings of England : Nottinghamshire* (Harmondsworth, Middlesex, 1951) p.143. See also C. ROBERTS, *Achievement : A record of fifty years progress of Boots Pure Drug Company Ltd.* (1938) pp.46-52.

(40) F. A. WELLS, "Expansion of the Engineering Industries" in "Nottingham in the National Economy", *Times Review of Industry*, Feb. 1955, p.61.

EAST MIDLAND RECORD

Polish Festival at the University of Nottingham

Official celebrations of the *Millennium Poloniae,* the thousandth anniversary of the emergence of Poland as a national entity, began this year and will continue until 1966. In order to honour this important occasion the University of Nottingham, in collaboration with the British Council and the Polish Cultural Institute in London, held a special Polish Festival of public lectures and exhibitions from 3rd to 13th November, 1960, which was inaugurated by H.E. The Polish Ambassador, Dr. W. Rodzinski.

Among the eminent scholars from Poland who gave lectures was Professor K. Dziewonski, Deputy Director of the Geographical Institute of the Polish Academy of Sciences in Warsaw, who spoke on "The Upper Silesian and Kraków Industrial District" and "Town Planning and Architecture in Poland To-day." Professor Dziewonski has held high posts in the field of planning in pre-war and post-war Poland and, indeed, began his career as an architect.

The Department of Geography, whose long-standing contacts with Poland have been cordially revived in recent years, was responsible for arranging an exhibition illustrating the country's past and present through the medium of maps. For this purpose the Department was fortunate in being able to borrow certain historical maps from the British Museum or to obtain photostat copies. Other maps were kindly loaned by the Royal Geographical Society, London, and the Geography Department of the University of Birmingham.

A second exhibition, specially prepared in Poland, was displayed in the University Art Gallery under the auspices of the Polish Cultural Institute. This exhibition, entitled "Warsaw Yesterday, Today and Tomorrow," showed by means of photographs and diagrams the vast scale of destruction the city suffered at German hands (largely as a reprisal for the ill-fated rising of 1944) and the impressive amount of rebuilding which has taken place in the last fifteen years. A third exhibition, illustrating "Warsaw at War," consisted of a series of macabre sketches by the artist Linke.

Apart from Professor Dziewonski, other Polish geographers visiting the Department in 1960 were Prof. J. Kostrowicki, Dr. L. Kosinski, and Dr. J. Paszynski, all from the Polish Academy of Sciences.

R.H.O.

Draft Proposals of the Local Government Commission.

The Local Government Act of 1958 set up a Local Government Commission for England empowered to recommend changes in the boundaries and status of administrative counties and their urban equivalents, the county boroughs. The Commission made draft proposals for their East Midlands and West Midlands General Review Areas early in 1960, and proposals for the York and North Midlands General Review Area may be expected to follow in the near future.

The East Midlands Review Area comprises the counties of Leicester (Leicester Administrative County and Leicester County Borough), Northampton (Northampton County Borough and the Administrative Counties of Northampton and the Soke of Peterborough) and Rutland, together with the counties of Bedford, Cambridge (Cambridge and Isle of Ely Administrative Counties) and Huntingdon. The latter three counties are not, by the way, usually considered by geographers to lie in the East Midlands.

The leading changes proposed for these six counties are :—

(a) The boroughs of Cambridge and Luton (Bedfordshire) to become County Boroughs, with extended boundaries. (The 1958 Act implies a population qualification of about 100,000 for county borough status.)

(b) A new administrative county to be formed of the Administrative Counties of Cambridge (excluding the new County Borough of Cambridge), Huntingdon, the Isle of Ely, and the Soke of Peterborough. (The Commission do not suggest either a suitable name for the new county or a location for its headquarters.) This new county would undergo alterations to its outer boundary, Stamford Borough being added from Lincolnshire, Ketton Rural District from Rutland, and Royston Urban District from Hertfordshire, while St. Neots Urban District would be transferred to Bedfordshire.

(c) Rutland, less Ketton Rural District in the east, to be added to Leicestershire, which already provides certain services for Rutland.

(d) The County Boroughs of Leicester and Northampton to have boundary extensions.

The elevation of Cambridge and Luton to county borough status and the boundary extensions for Leicester and Northampton can be justified by the substantial urban growth which has taken place since the mid-1930's, when local government areas were last overhauled on a systematic basis. Even so, the extensions recommended for Leicester will still leave many suburban areas under the jurisdiction of the county. Not only this, but part of the built-up area of the city, taken from the county in 1935, will be transferred back to the parish of Birstall, if the proposals are implemented. One interesting effect of the Leicester extension would be that Leicester would be able to challenge Nottingham's position as the most populous city of the East Midlands, the more so as boundary extensions are unlikely at Nottingham. Nevertheless, the whole Nottingham conurbation, with its population of about half a million, would still maintain its considerable lead over Greater Leicester.

The most controversial recommendation is that proposing the extinction of the five administrative counties mentioned above in (b) and (c) The Commission assert that they can no longer be considered as suitable units for the exercise of county functions. In their own words :—"This is not a question of efficiency or inefficiency but of whether the areas, populations, resources and case loads of these particular authorities provide the conditions which make it possible to

develop comprehensive and fully effective local government services in present-day conditions." The new county, with a population of 320,000, "would be a strong but not over-large authority capable of providing a comprehensive and fully effective range of county services and of developing these as the need arose."

Vigorous opposition to this scheme was voiced at the local conferences held by the Commission to discuss the proposals. Rutland, in particular, is carrying on a spirited campaign for its preservation; motorists encounter notices informing them of Rutland's "fight" as they cross the county boundaries. The next stage in the official procedure, as laid down by the Act, will be the submission of the Commission's final proposals to the Government, to be followed by local inquiries where objections are made. Finally, the necessary orders authorising such changes as are approved by the Government will be presented to Parliament.

In one instance the draft proposals for the West Midlands Review Area indirectly concern part of the East Midlands region. The Commission propose the conversion of Burton upon Trent from a county borough to a non-county borough under Staffordshire County Council, on the grounds of its inadequate population size (49,000). Furthermore, the Commission do not consider either that its population is likely to grow substantially or that Burton could "reasonably be enlarged in area so as to make a material increase in its population." Burton upon Trent strongly disputes this latter argument and has put forward a case for union with the built-up areas of the South Derbyshire coalfield (notably Swadlincote Urban District), which lie immediately to the east of the town. In this manner county borough status would be preserved and the community of interest already existing would be officially recognised.

Draft proposals for Derbyshire, Lincolnshire and Nottinghamshire have yet to be made, as the Commission have not finished their work in the York and North Midlands (sic) Review Area. Controversial proposals might well be expected to concern the following:—the expansion of Derby County Borough, the future of Sheffield's suburbs in north-east Derbyshire, possible adjustments of the Derbyshire-Nottinghamshire boundary, which presents many anomalies in the thickly-populated coalfield and Erewash valley, and the future of the three administrative counties of Lincolnshire.

R.H.O.

Meteorological Records at Nottingham.

Climatology in this country owes a great debt to the amateur weather observer. Mr. A. B. Tinn, who has made several contributions to this journal, is not only an outstanding example of the type: his interests go further, into the field of analysis. He has now been recording a wide variety of weather elements at Woodthorpe, Nottingham, continuously for a quarter of a century, and has recently completed a summary and analysis of his records for the period 1935 to 1958 in the form of averages, frequencies and extremes. This alone is the product of an enormous amount of patient computation; but to the many-sided analysis of the Woodthorpe data, including correlations of maximum and minimum temperatures and humidity with wind direction, are added

further tables which relate the temperature records at Trent Lane, Nottingham; Burford Road, Nottingham; Attenborough, Strelley, Chilwell, Watnall and Sutton Bonington, as well as those at Woodthorpe, to the long-period record kept at Nottingham Castle, and thus to each other. We are thereby given an accurate indication of how temperature varies over the Nottingham district. Mr. Tinn's work represents a major contribution to local climatology.

A copy of the meteorological record for 1959 compiled at Chandos Boys' County Secondary School, Netherfield, Nottingham, has been received by the Department of Geography. Daily readings taken by boys of the school's Meteorological Society, under the guidance of Mr. J. F. Fox, have been presented as monthly and annual summaries of the various weather elements supported by brief descriptions of the main weather patterns which help to explain the figures. Such an enterprise has an obvious educational function in its emphasis on co-operative effort, accuracy and objectivity, persistence (the readings continued through the school holidays) and the scientific attitude in general, and in its introduction of a real problem as a basis for simple statistical training. It also has an intrinsic value as a piece of original work, on which the school and the boys concerned are to be congratulated. It would be interesting to hear of similar projects in the East Midlands.

The 1959 record from Chandos School affords an interesting comparison with that from Woodthorpe. In most instances the figures are closely similar, but in others they are significantly different. For example, in most months Chandos School measured less rainfall than Woodthorpe, but summer storms almost redressed the balance, Woodthorpe's annual total being 19.54 inches compared with the 18.22 inches at Netherfield, on lower ground. These figures may be compared with totals of 18.65 inches at Mapperley and 18.17 inches at Trent Lane in the very dry year of 1921. The sunshine record shows that Netherfield enjoyed less sunshine than Watnall, north of Nottingham, in every month of 1959 except October, when it recorded the same duration. Over the whole year Chandos School recorded 1,390 hours and Watnall 1,573 hours.

F.A.B.

XIXth International Geographical Congress

The Xth General Assembly of the International Geographical Union and XIXth International Geographical Congress were held in July-August, 1960, in "Norden" (Denmark-Finland-Iceland-Norway-Sweden). In addition to the main congress in Stockholm, from 4 to 13 August, an extensive programme of symposia and excursions was arranged in various parts of Norden in the preceding and following weeks.

The Stockholm meeting was attended by Professor K. C. Edwards and Mr. F. A. Barnes from Nottingham University Department of Geography. Professor Edwards acted as deputy leader of the large British delegation. Together with Mr. G. R. Crone he submitted a Report to the Congress on "Geography in Great Britain 1956-60": this was later published in The Geographical Journal. After the Congress Professor Edwards took part in a symposium at Lund (Sweden) on Problems of Urban Geography, contributing a paper on "Trends in

central area differentiation". Mr. Barnes and Dr. C. A. M. King attended a symposium on Coastal Geomorphology at Esbjerg (Denmark), where they presented joint papers entitled "Changes in the configuration of the inter-tidal beach zone of the south Lincolnshire coast since 1951" and "Morphological development of salt marsh at Gibraltar Point, Lincolnshire".

At the Stockholm meeting a former student of the Nottingham Department of Geography, Professor K. B. Cumberland, Professor of Geography in the University of Auckland, was elected one of the six vice-presidents of the International Geographical Union.

HIGHER DEGREE THESES AND FIRST DEGREE DISSERTATIONS

Prepared in the Department of Geography

In the University, Geography may be read as a subject in the Faculties of Arts, Law and Social Sciences, and Pure Science. Since the award of the Charter to the University in 1948 all students taking an Honours degree in Geography have been required to submit a dissertation as part of their final examination. Only those dissertations and higher degree theses relating to East Midland subjects are listed below. *Bona fide* students or research workers may apply for permission to consult them in the Department.

1960

M.A.

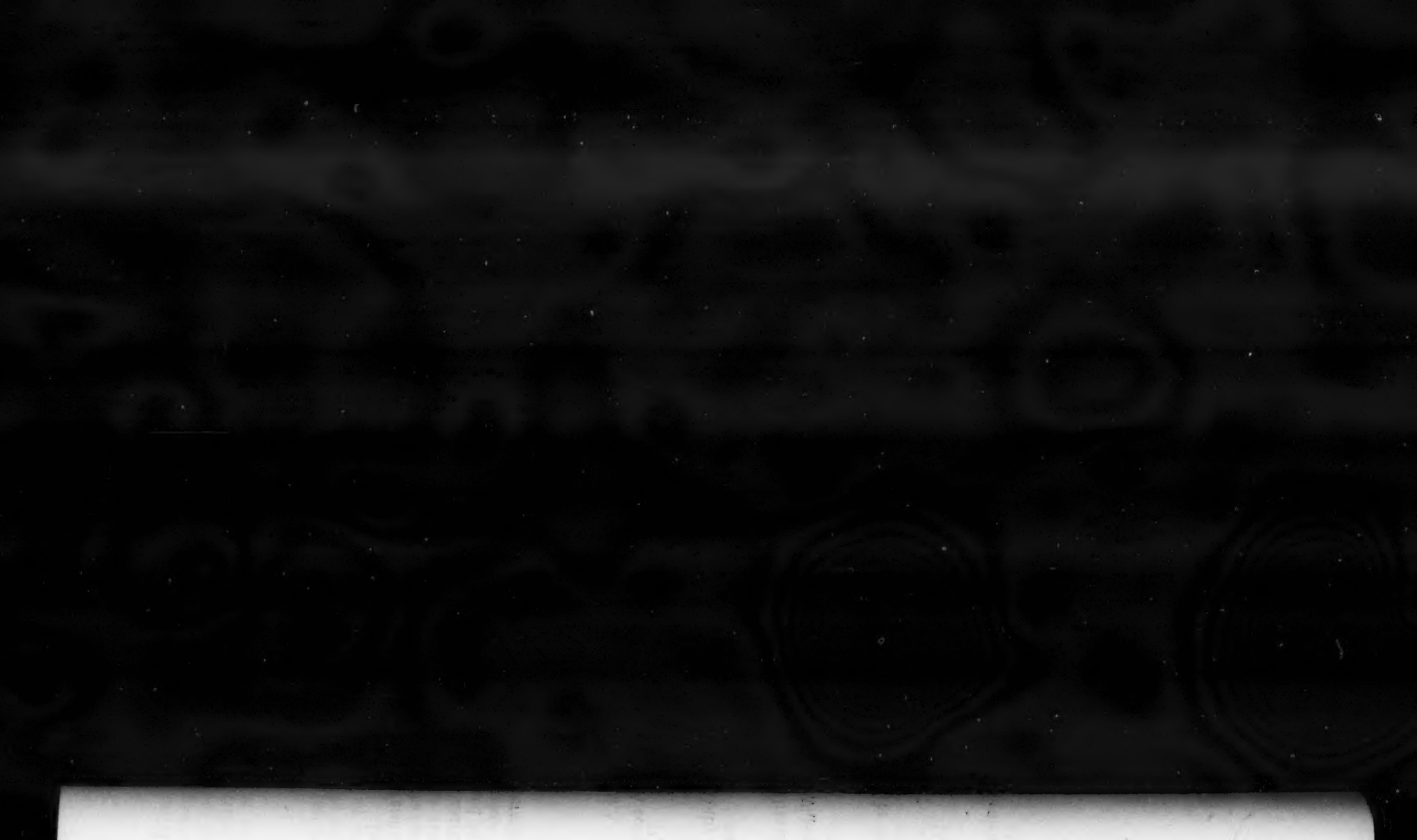
A comparative study of the urban development of York and Lincoln. P. A. Grimshaw.

Corby New Town: a geographical study from a local, regional and national standpoint. D. C. D. Pocock.

DISSERTATIONS

Whittlewood Forest and the surrounding parishes from the eighteenth century to the present day. C. M. Lees.

The development of settlement in the Bradley-Haverstow Wapentake of Lindsey from the eighteenth century until the present day, with an initial investigation of the early pattern as established in Domesday. P. A. Trotter.

Settlement, agriculture and industry in a part of south Leicestershire. H. P. Turner.

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